Raw Silk and Throwing

W. P. Seem

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BY

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FIRST EDITION

PUBLISHED FOR THE
TEXTILE WORLD
BY
McGRAW-HILL BOOK COMPANY, Inc.
NEW YORK: 370 SEVENTH AVENUE
LONDON: 6 & 8 BOUVERIE ST., E. C. 4
1929

PRINTED IN THE UNITED STATES OF AMERICA

THE MAPLE PRESS COMPANY, YORK, PA.

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PREFACE

In presenting to the silk industry this treatise on RAW SILK AND THROWING, the author gives a collection of practical experiences and researches on silk problems which he dedicates as a source of information to those who aim to make the silk business a life work.

The author hopes that the book will help to advance the cause of better practice in the industry and that through encouraging better practice it may help the industry to give greater service to the public.

In RAW SILK PROPERTIES, CLASSIFICATION OF RAW SILK and SILK THROWING, the author presents methods of measuring the qualities of raw silk. These methods have for five years been given practical application to the problems met with in the knitting of hosiery and fabrics and have been found dependable. They are therefore well beyond the experimental stage.

It is proposed to show in this book the need of correct information on the raw stock as essential to scientific management. This information is highly important to those interested in the throwing of raw silk thread and also to the users of raw and thrown silk.

The author counts it a privilege to have been one of the pioneers in advocating and promoting the testing of raw silk by the throwster. It is consequently highly gratifying to find that the number of throwsters introducing laboratories in their plants is constantly increasing, and that the experience of a few pioneers is proving sound in practice.

The author gratefully acknowledges courtesies that have made possible the publication of the information contained in this book.

WARREN P. SEEM.

RICHMOND HILL,
NEW YORK CITY, N. Y.
April. 1929.

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RAW SILK AND THROWING

PART I

MEASURING, CLASSIFYING AND DISPOSITION OF RAW SILK

The properties of raw silk are variously known as follows: color, luster, hand, nerve, "nature," strength, elasticity, elongation, cohesion, evenness, cleanness, and size. Since different classes of silk thread and different silk products require different qualities of raw silk, it is necessary to know how to interpret the qualities and determine which are essential to the manufacture of a specific thread or product. The importance of correctly judging or measuring these qualities before throwing and manufacturing is quite apparent. The first quality we will consider is color.

Color in Raw Silk

The color generally is classified as white, ivory, and cream. It is usually determined by a visual inspection of a book or a number of skeins. A better way is to select six white, six ivory, and six cream skeins, putting them in a shallow box and using them as standards to match up samples with. The samples should be kept covered to prevent fading when not in use. It is advisable to use a daylight lamp so as not to delay inspection while waiting for proper natural light.

The object of classifying color is to get level shades in dyeing. Studies have been made by different investigators to determine the characteristics of raw silk that govern the affinity for dyestuffs, but so far no definite information has been obtained. Our experiments show that white and ivory-colored silks, of a soft nature, appear as different shades when dyed in the same bath with a silk of a cream color and of a hard nature. There

is no difficulty in picking out the soft- and hard-natured silks or the white and cream shades by the sense of sight and touch. However, it is sometimes impossible to differentiate between silks that are neither hard nor soft, and it is in these cases that the senses of sight and touch and good judgment fail and a scientific method is found desirable.

The innate qualities of silk are the qualities belonging to the essential nature of the thread. These are variously called strength or tenacity, elongation or ductility (also wrongly called elasticity), luster, hand, nerve, "nature," and cohesion. Experience shows that these can be grouped into four measurable qualities as follows:

Strength (also comprising what is known as nerve), elongation (also called ductility), cohesion, and elasticity (as representing the quality upon which luster and hand are dependent). The combined value of the first three qualities is sometimes called "nature."

Strength of Silk Threads

Strength is the resistance of the thread to being broken, and is measured by the force required to break it. Measurements are made on the serigraph and serimeter (see Figs. 1 and 2). As silks vary in size, and the strength of a thread is in proportion to its diameter (count or denier), one cannot take a single thread and determine whether the thread is inherently strong or weak from its breaking strength alone, but one must consider it in terms of its breaking force in grams as related to its denier size. As wearing qualities are found to be in direct relation to the inherent strength of the silk thread, it is considered an important test.

The Raw Silk Classification Committee considers silk low in strength when it measures under 3 g. per denier on the serigraph, and under 3.50 g. per denier on the serimeter. This concurs with the author's experience. I have found that silk showing a low strength rating, as given above, becomes fuzzy and lousy. The fabric also has a poor hand. Silk low in strength is unsuitable for thread and fabric where strength and wearing qualities are essential.

The advantage of using the serigraph in testing strength is that a better average is obtained as on a $^{13}/_{15}$ denier silk 400 threads are used in the test. The test also can be made quicker.

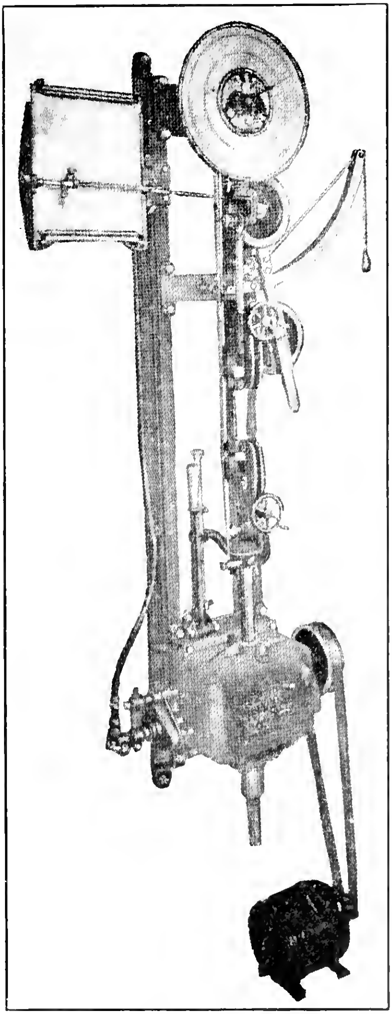


FIG. 1.—Serigraph used in silk testing.

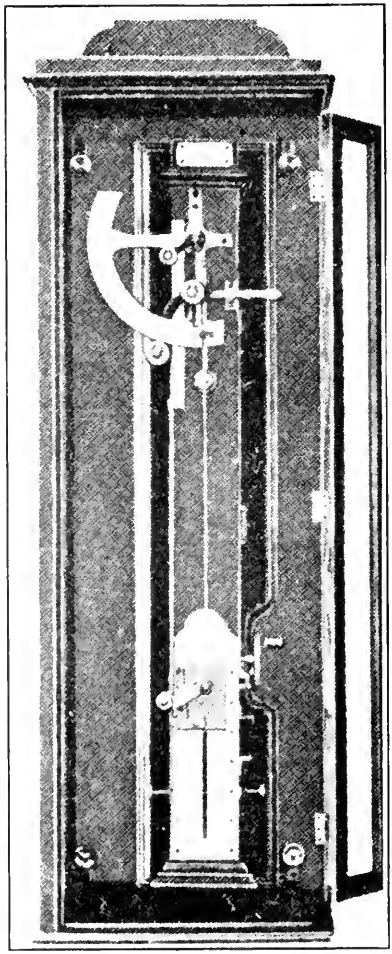


FIG. 2.—Single-strand serimeter for testing silk.

ELONGATION OR DUCTILITY

Elongation is the total stretch per unit of length produced by a tensile force. Professor Hagihara finds that elongation of a

silk thread consists of three elongations; *i.e.*, the elongation of the fiber itself, a surplus due to irregular doubling in reeling the cocoon, and the atmospheric effect.

In "Raw Silk Properties, Classification of Raw Silk, and Silk Throwing," the author says that "as all silks are ductile enough in a humid atmosphere to meet all throwing and manufacturing requirements, it appears that elongation, also called ductility, need not be measured or considered in classifying raw silk."

Further studies on this property, however, show that at the close of each silk season we receive some silk in which one or more cocoon fibers break and cause split threads when the thread is put under tension. We also find silks where as many as 50 per cent of the threads do not elongate more than 8 per cent, or are brittle against pull. Such silks are unsuitable for anything but low-grade tram.

When the threads with only 8 per cent elongation are doubled with others having over 14 per cent elongation and any unusual tension is put on the doubled thread, the thread with low elongation breaks and causes a split thread. If these threads (one having 8 per cent elongation and the other over 14 per cent elongation) get into a knit fabric, some of them break and cause pin holes. When the tension is put on the warp in weaving, the threads that are low in elongation also break and cause delays in weaving. When they pass through, they sometimes break during the dressing and also cause holes in fabrics.

Rosenzweig, in *Serivalor* (1904 and 1917 editions) and again in the March, 1926, issue of the *American Silk Journal*, states that elongation is a disadvantage in weaving and is a visible sign of weakness. He states that shiny stripes in the warps are due to elongation. Our researches show that a thread or fabric high in quality cannot have a great number of threads that are brittle against pull or low in elongation. Therefore, this property must be considered in classifying raw silk. As brittleness is not always indicated by a medium elongation on single threads and never on multiple threads, one must use the number of threads that elongate 8 per cent and under as the basis of elongation value, and must rate elongation by its defects or threads brittle against pull.

Cause of Brittleness

Investigations were made as to what causes threads to be brittle against pull; and I am told by one who is familiar with conditions in the filature that brittle threads are undoubtedly due to excessive speed in reeling the wet cocoons, thus permanently elongating the fibers.

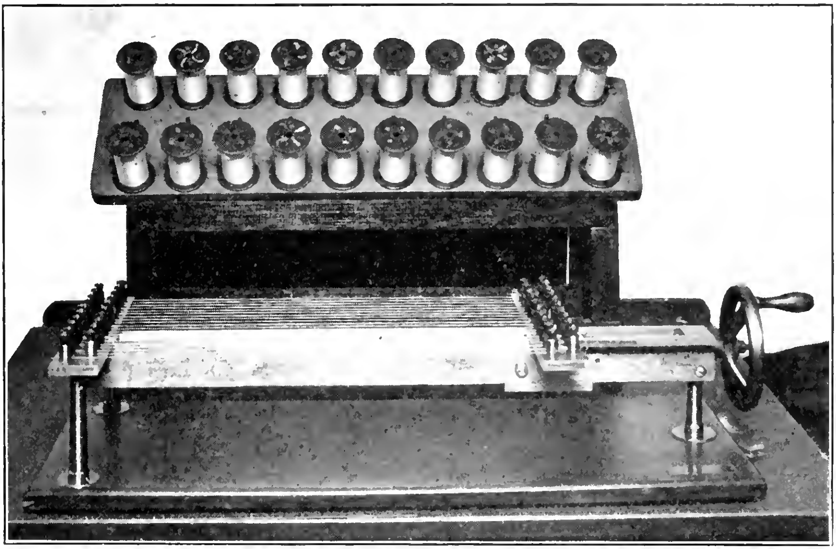


Fig. 3.—Machine for testing brittleness of silk thread.

As elongation is very susceptible to atmospheric conditions, great care must be taken that the tests are made under standard air conditions, or at a temperature of from 70 to 75° F. and a relative humidity from 65 to 70 per cent. The brittle threads may be measured on a single-strand serimeter, shown at Fig. 2, or on a brittleness machine, shown at Fig. 3. The brittleness machine is a multiple serimeter for testing the elongation on 20 single threads, 50 cm. long. The stretching is done by means of a screw operated by a hand wheel. A dial graduated in percentage and inches is fastened to the frame. The machine is stopped at certain intervals to count the number of threads broken. To avoid an initial tension and irregular results by different operators, a paper clip is fastened to the loose end of

the thread and the thread is drawn taut before fastening the loose end to the binding post. Check tests made on a serimeter were found to be within one half of 1 per cent of those made in the brittleness machine.

Average elongation cannot be correctly measured on a serigraph on multiple threads, for frequently as many as 20 per cent of the threads break before the maximum stress is reached, and at other times 20 per cent or more of the threads have not fully elongated when the breaking point is recorded on the diagram.

The following table gives the result of 58 elongation tests, showing, in the first column from the left, the average elongation on 20 single threads. The second column represents the number of threads that broke when elongated up to 8 per cent. The third, fourth, and fifth columns indicate the number of threads which broke when elongated to 10 to 14 per cent and over 14 per cent, respectively.

The last column represents the elongations as recorded on the serigraph diagram at maximum stress. These were made on 300 and 400 threads, according to size. The sizes represented in the tests ranged from $^{10}/_{12}$ to $^{20}/_{22}$ denier.

Note the following conditions shown by the preceding tests:

1. Where the elongation varies from 12 to 12.9 per cent on the single thread, it ranges from 17 to 20 per cent on the serigraph, and there is no consistency between the elongation on single and multiple threads.

2. As the average elongation increases on single threads, the number of brittle threads, or those elongating under 8 per cent, gradually decreases. There are no brittle threads in the 17 per cent group, and only a few in the 16 per cent group. Therefore, high elongation on single thread indicates uniformity, of elongation, and low elongation indicates a lack of uniformity, or, in other words, brittleness.

3. Since there are exceptions in the 14 and 15 per cent classes, and since no strict dividing line exists, the brittle threads cannot always be determined by the average elongation; hence the low readings must be taken to find the defects in elongation or brittleness.

Elongation Tests

Average elongation, per cent	Number of threads broken				Elongation on serigraph, per cent
	Under 8 per cent	Under 10 per cent	Under 14 per cent	Over 14 per cent	
11.1	5	10	20	..	16
12.7	4	7	16	4	19
12.4	2	6	17	3	20
12	4	8	16	4	18.5
12.5	3	6	15	5	18.5
12.2	1	4	15	5	18
12.9	3	7	17	3	18.25
12.4	3	8	16	4	17
Average...............	3	6	16	4	
13.4	2	7	14	6	15
13.2	3	8	20	..	15
13.6	1	4	11	9	15
13.9	1	5	12	8	19
13.7	2	5	12	8	18
13.5	3	6	16	4	18
13.3	2	6	13	7	19.5
13.2	2	4	15	5	18.5
13.7	3	5	14	6	16.5
13.2	2	4	16	4	20.75
13.2	3	7	14	6	18.25
Average...............	2	6	15	6	
14.9	..	..	10	10	19.6
14.6	..	1	13	7	17.5
14.8	..	2	7	11	18.5
14.4	..	3	12	8	19.25
14.8	..	1	9	11	17.4
14.4	2	4	15	5	17
14.3	1	3	18	2	17.5
14.3	2	3	10	10	18.6
14.8	1	2	8	12	20.5
14.1	2	3	10	10	23.75
14.2	4	5	6	14	18.5
Average...............	1	3	11	9	
15.9	1	2	7	13	19
15.2	..	1	8	12	18.5
15.2	1	2	15	5	17.5
15.6	..	1	9	11	17
15.4	1	2	10	10	19.75
15	..	1	10	10	20
15.5	..	2	12	8	20.5
15.7	..	1	5	15	17.5
15	3	5	16	4	18.5
15.7	1	2	6	14	17
15.3	1	2	7	13	18
15.6	..	1	4	16	17.25
Average...............	1	2	9	11	
16	..	..	5	15	19
16.6	..	1	5	15	25.5
16.2	1	2	6	14	22
16	1	2	3	17	19.5
16.7	..	2	5	15	22
Average...............	..	2	5	15	
17.3	..	1	2	18	19.25
17.1	..	..	2	18	19
17.2	..	1	5	15	20
17	..	..	5	15	19.5
17.2	..	1	4	16	20
Average...............	..	1	3	17	
18.2	..	1	4	16	20.5
18.7	..	..	1	19	19.5
18.2	..	1	3	16	17.5
18.2	..	..	1	19	22.75
Average...............	..	..	2	18	
19.5	..	0	1	19	22
19.6	..	1	2	18	23
Average...............	..	..	2	18	

"Nature" of Silk

Studies were made on the strength and elongation values of the 58 tests given on page 7 to find out whether there was a correlation between strength and elongation, and whether a combination of the coefficients of elongation and strength represent the "nature" of silk.

It will be observed that even though the low elongation values indicate many brittle threads, as may be seen in the

Strength and Elongation Values

Per cent elongation (made on single thread)		Per cent strength (made on multiple thread)	
	Average		Average
12 to 12.9	12.4	87 to 97	92
13.2 to 13.9	13.4	83 to 99	92.8
14.2 to 14.9	14.5	86 to 96	91
15 to 15.9	15.4	85 to 92	90
16 to 16.7	16.3	90 to 97	94
17 to 17.3	17.1	90 to 99	92
18 to 18.3	18.3	89 to 91	90
19.5 to 19.6	19.5	91 to 93	92

12 and 13 per cent elongation groups, the average strength is as high as the 17 per cent elongation group where no brittle threads are indicated. As the brittle threads apparently exert no influence on the average strength, but a decided influence on the average elongation, it indicates that no correlation between strength and the average elongation on multiple threads at the breaking strain can exist, from which a "nature" value might be interpreted.

In Appendix C to the Raw Silk Classification, 1926 report, Cheney Bros. recommend for study the nature test, which they find is a combination of tenacity, elongation, and elasticity obtained from the graphic chart made during the serigraph test.

The results of 53 tests made on the serigraph, with the graphic charts interpreted according to Cheney Bros.' method of determining nature, follow:

STRENGTH AND NATURE TESTS

Grams per denier	Strength, percentage	Nature, percentage	Average strength	Average nature
3	80			
3.04	81			
3.08	82			
3.12	83			
3.16	84	73–71		
3.19	85	72–69	84	71.2
3.22	86	77–72–74–71		
3.26	87	76		
3.30	88	74–75		
3.34	89	73–77–82–76		
3.37	90	79–75–76–79–78–75–79	88.5	76.06
3.40	91	78–75–82–76–81		
3.44	92	80–84–86–83–86		
3.48	93	79–83–83–84–80		
3.52	94	81–86–80–85		
3.56	95	81–85–81–87	93.1	82.09
3.60	96	90–86–86		
3.63	97	93–87		
3.67	98			
3.71	99	87–89–85		
3.75	100		97.3	87.7

The first column represents the grams per denier as found on the serigraph; the second shows the grams per denier converted to percentage on a basis of 3.75 g. representing 100 per cent; the third column represents the individual readings on the

diagram interpreted as nature; the fourth column represents the average strength of each group; and the fifth column the average nature of each group.

The consistency between the strength and so-called nature readings on the individual tests as well as on the average of the groups is so constant that it indicates that both represent the same characteristics of raw silk.

This will be clearly seen by grouping the averages of the strength and nature results as follows:

	Percentage		Percentage
Strength average.......	84	Nature..............	72
Strength average.......	89	Nature..............	76
Strength average.......	93	Nature..............	81
Strength average..	98	Nature..............	90

These tests, while indicating that a consistent correlation exists between the strength and Cheney Bros.' interpretation of the stress-strain diagram, they do not however present any proof that the coefficient or effect produced is another characteristic of raw silk that might be called nature.

ELASTICITY

Elasticity, according to physicists, is the power which a body possesses of returning to its original shape and dimensions after the forces which have been applied to it are removed. It is the quality of a silk thread that produces what is called "hand" in silk fabrics.

Professor Hagihara says: "If we take in hand a mass of fabric, thread, or cloth, we feel it full in the hand. It is the property of filling which make the goods voluminous and may also be called "fullness of hand" or simply "hand." This property is dependent on nothing else than the elasticity of silk. The elasticity is affected by the aggregate forms and the cemented condition of the fiber, besides the elasticity of the fiber itself."

He further states: "There are no means of directly measuring elasticity from the load-strain diagram of a given thread."

The Raw Silk Classification Committee, in their 1926 report, state that elasticity is the limiting force, expressed in grams per denier, which the thread will just support without permanent elongation. It is indicated in the test by the yield point on the serigraph record at which the straight-line portion ends and the diagram becomes curved.

An investigation of the yield point as interpreted by the Raw Silk Classification Committee also follows the strength value so closely that we cannot find a different characteristic that might be termed elasticity.

We find that a knit fabric having a good hand always has good come-back forces when stretched. This is properly called "elasticity." Such fabrics also possess good strength. A knit fabric may elongate or stretch readily, but come back weakly. Such fabrics are low in strength and are called poor in elasticity.

A method of measuring elasticity appears to have been developed during our researches on nature and is presented herewith:

A METHOD OF MEASURING NATURE

Further studies indicate that the property of raw silk called "nature," and classified as hard, medium, and soft, is a condition due to the molecular cohesion or hardness of the sericin.

To this property of the cocoon filament, the degree of cohesiveness of the sericin is undoubtedly due; however, in the commercial thread nature cannot always be determined by the cohesion test as a thread reeled from cocoons high in molecular cohesion may show a low cohesion due to improper reeling methods.

Nature is an important property, as it governs the affinity for dye stuffs, boiling-off time, tendency to lousiness and fuzziness, and the selection of silks suitable for tin weighing and crêpes.

The degree of hardness controls the pliability of raw silk and upon that quality depends the successful treatment of the thread intended for crêpes, raw weaves, and gum knit hosiery.

In building methods of testing nature in the laboratory of the Julius Kayser Co., we decided to pursue our researches at the wearing strain instead of the breaking strain of the real fiber or in the dyed state, but conducting tests on the raw silk, thus saving much time and expense in testing.

Silk stretched wet at 1.4 g. per denier elongated 7.9 to 8.4 per cent or an average of 8.5 per cent. The elasticity varied from 51 to 52 per cent, or an average of 51.3 per cent.

The same silk boiled off and stretched dry at 2½ g. per denier elongated 7.9 per cent to 8 per cent and showed an elasticity of 46 to 50 per cent or an average of 49.2 per cent.

Studies made to determine how much more elasticity remained in the gum silk when stretched wet at 1.4 g. per denier indicate the following:

Grams per denier	Elongation percentage	Elasticity percentage
1.4	9.5	55
1.65	11.75	51
2.5	17	45
3	22.25	38

The same silk boiled off and tested showed:

Grams per denier	Elongation percentage	Elasticity percentage
1.4	8.75	60
2	16.5	45
2.5	22.75	37

The tests on the gum silk shows that when the stress was increased from 1.4 to 1.65 g. that the elasticity decreased 4 per cent and indicates that the fiber had broken down and that 4 per cent permanent elongation, or strain, had been produced.

On the same silk boiled off the test on 1.4 g. shows an increase of 5 per cent elasticity indicating no breaking down of the fiber at that stress.

Tests made on knitting and wearing strain indicated that 1.4 g. per denier closely represents actual operation and wear and it was adopted as the standard stress for our studies.

Description of Test

Samples are wound from 40 skeins extracting 10 skeins from each of 4 bales of a 10-bale lot.

Five skeins, 45 meters long are reeled from a five-bobbin creel. The bobbins are changed after 22½ yd. of five thread are reeled, and the skeins completed from the second set of five bobbins. The five skeins thus represent 225 meters of single thread 22½ meters from each of 10 skeins from a bale. These skeins are weighed in deniers.

A machine was built somewhat similar to that used in the Lee test, but with a chart recording the elongation and quick comeback which tentatively is called elasticity.

Method of Test

The skeins are dipped in water, and hung wet on the binding posts in the machine. A stress of 1.4 g. per average denier is gradually applied to the skein, and when the stress is reached the pressure is quickly removed and the skeins are allowed to contract. A pen records the elongation and elasticity on a chart, and the measurements are read in percentages.

A summary of about one thousand tests indicate the following:

Nature	Elongation percentage	Elasticity percentage
Hard	9.25 (and under)	59 to 61
Medium	9.26 to 10.	58 to 60
Soft	10. to 10.75	54 to 58
Very Soft	10.75 (and over)	50 to 54

Tests made on Canton show:

High-grade Canton	Percentage	Low-grade Canton	Percentage
Elongation..........	10.70	Elongation..........	10.96
Elasticity...........	54	Elasticity...........	54

(Note that the Cantons get into the very soft class.)

A summary of 61 tests shows the relation of elasticity to nature:

Number of tests	Nature			Elasticity percentage
	Low	High	Average	
4	10.20	10.50	10.29	54
8	9.43	10.12	9.70	55
10	9	9.94	9.38	56
13	8.79	9.79	9.30	57
9	8.70	9.84	9.13	58
7	8	9.86	9.16	59
2	8.24	8.04	8.14	60
8	8.19	9.18	8.08	61

A summary of 29 tests gives the relation of elasticity to strength:

Elasticity	Number of tests	Strength	
		Range	Average
54	1		96
55	3	95 to 95	95
56	2	98 to 98	98
57	9	96 to 105	99
58	8	95 to 102	99
59	2	101 to 102	101
60	3	96 to 104	99
61	1	96	96

A summary of 28 tests to study the relation of strength to elongation shows:

Strength	Number of tests	Elongation	
		Range	Average
95	5	9.45 to 10.39	9.87
96	6	8.20 to 9.89	9.28
98	5	8.49 to 9.42	9.11
99	1	9.70	9.20
100	4	8.85 to 9.02	8.94
101	2	8.60 to 9.38	8.99
102	3	8.79 to 9.58	9.22
104	1		8.14
105	1		9.16

Our deductions from these and other tests are:

I. As there is a consistant relation between elasticity and elongation wet at 1.4 g. per denier, it indicates that elasticity is evidently dependent on elongation.

II. Elasticity consistantly follows strength; but has a sufficient number of exceptions to indicate the influence of another property.

III. Elongation is evidently dependent on strength, but as there are a number of tests where no direct relation exists, it also indicates another property influencing the result. The direct relation of these measurements to gum-knitting operations, the action of water on hard, medium, and soft nature silks, cohesion tests made on cocoon filaments and on the commercial thread of known nature, indicate without doubt that the nature of raw silk is indicated when the gum silk is stretched wet at a stress of 1.4 g. per denier.

Cohesion in Raw Silk

The raw silk fibers, as spun by a silkworm, consist of two filaments, 500 or more yards long, the core of which (about 80 per cent) is the real fiber and is called *fibroin*. The outer coating

consists of a silk glue, called *sericin*. As the worm does not add any twist in spinning the fiber, nature has provided a silk glue to cement the two filaments into a compact thread.

A study of the cocoon fiber shows that the worm does not always add the sericin uniformly, but more or less irregularly. The worm, in spinning, lays the fiber in the shape of a figure eight around its body. The fiber and glue harden and form what is known as a *cocoon*. While the sericin hardens as soon as it comes in contact with the air, it remains soft enough to glue the fibers together into a compact mass constituting the cocoon.

To reel this fiber into a commercial thread, the cocoons are soaked in hot water, which softens the sericin to such an extent that the fiber readily unravels. Four or more cocoon fibers are doubled together in reeling to form the raw silk thread. In the reeling process, the threads are caused to twine around each other a number of times (called a *croisure*), and, as the sericin is soft and sticky when wet, the fibers become agglutinated into a compact thread. The force that causes these cocoon fibers to stick together is called *cohesion*. Cohesion is considered in physics as the mutual attraction of the particles of a solid for one another and is measured by the amount of force that must be applied to overcome it. We thus see that the term "cohesion" is properly applied to this quality of raw silk thread.

A good cohesion depends, *first*, on the molecular cohesion of the sericin or silk glue; *second*, on a proper croisure in reeling the thread; and *third*, on proper reeling methods. Investigations show that the sericin and fibroin come from the same source, and that the higher the quality of the real fiber or fibroin, the more cohesive is the sericin; therefore, there is found to be a direct relation between the cohesion of a raw silk thread and its innate qualities.

There are times when the cocoons are not softened uniformly previous to reeling, and they unwind very irregularly, causing threads to twine loosely around each other in the form of a corkscrew. If such a thread is thrown into tram with no twist on the single thread, it is found to boil off wavy or flossy and the finished fabric is dull in luster and wavy, wooly, or hairy in appearance.

Friction in Weaving

In weaving raw silk in the gum, the thread is subject to friction as follows: *first*, when the threads lash against each other as the shed opens and closes; *second*, when the harness lifts and drops, exerting an opening effect and also a tension on the thread; and *third*, when rubbed 500 to 600 times by the reed on every inch of the thread.

A thread that opens readily is, therefore, unsuitable for weaving in the gum. In China filature and hard-nature Japan, we receive lots that are high in cohesion but give poor weaving results because the thread is rough, principally due to lime and magnesia in the gum.

Raw silk defects that affect weaving results and indirectly influence cohesion are loopy threads and corkscrews. When the cohesion is low and the thread is easily opened, the slack fibers of corkscrews and large loops split off, weaken the thread, and often cause a break. If the cohesion is high, these loops may break off and collect as lint behind the harnesses and reeds, but the thread goes through without a break. When the loops are numerous and long enough to show when one looks across the face of the warp or the fabric, then, when dyed, the outstanding filaments reflect light, give the fabric minute shaded places, and cause a dull appearance.

Conditions that affect cohesion are: high humidity, improper soaking, and keeping the thread wet too long. Italians and soft-natured Japans have a soft sericin which is partly soluble in water, hence, they lose as much as 50 per cent of their cohesion in soaking, and as much as 75 per cent if kept wet too long after soaking.

Measuring Cohesion

During my early experience and researches on cohesion, I assumed that, since it was friction which opened the thread on the loom, it required a friction machine to measure the compactness of the thread and determine its suitability for raw weaves. Up to 1916, cohesion was called friction, and was first properly named cohesion by Rosenzweig in his book, "Serivalor."

In measuring the soft-gummed and smooth silks on the friction machine, the weaving results and the tests agreed when all the thread and mill conditions were favorable; but, when testing Chinas and hard-natured Japans, there were often serious disagreements. For instance, rough silks, tested unsoaked on the friction machine, even though they had a high cohesion, rubbed through before the threads opened, and gave a low value; weaving results on the same silk soaked, gave good results, thus showing a great disagreement between the test and practical weaving results.

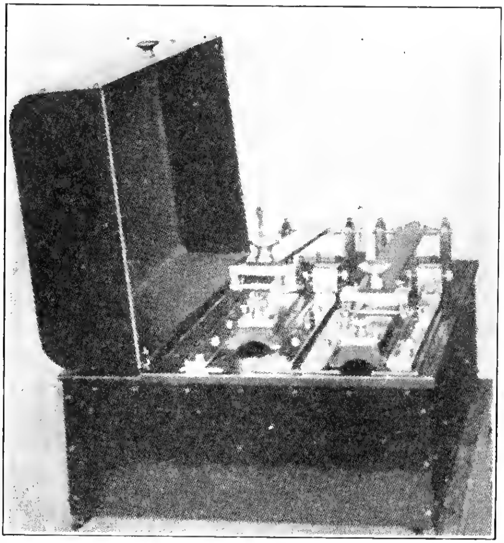


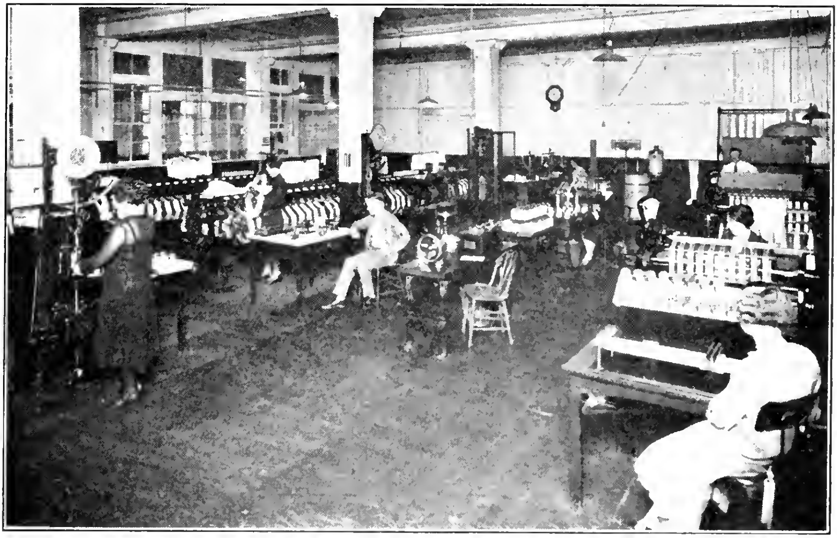
Fig. 4.—A cohesion machine.

Chinas and hard Japans gave poor results on both the friction machine and looms, while it was afterwards found that the silk was high in cohesion, and quite suitable for raw weaves. The results indicated by the friction machine used to measure cohesion were incorrect, as the thread rubbed through before the fibers were open, thus giving a false reading. The poor weaving results were due to the lack of proper lubrication of the thread and a very dry atmosphere in the weave shed.

These and other disagreements indicate that the measurement of cohesion cannot be subject to these conditions. A

machine was invented, using a $\frac{1}{4}$-in. roller set at an angle of $2\frac{1}{2}$ deg., with which the rough and smooth threads can be measured correctly. The cocoon thread (bave) consists of two filaments which can also be separated without breaking, and a relative value will be indicated. A cohesion machine is shown in the accompanying illustration (see Fig. 4).

Disagreements between results obtained on the cohesion machine and weaving results were found due to the following conditions:



First, a dry mill room with only 40 to 50 per cent relative humidity at a dry temperature of 70 to 80° F. A dry atmosphere caused the reeds and harnesses to cut the thread quickly and made the threads break more readily. For good weaving results one must maintain a relative humidity of 65 to 70 per cent at a dry temperature of 70 to 75° F.

Second, soft-natured silks were soaked and kept wet too long. In some cases, over half of the cohesion was destroyed. Some silks should not be soaked, but should be evenly oiled. To determine whether a silk should or should not be soaked, make two cards from the same threads, test the first one as it is, soak the second card in lukewarm water for a few seconds, dry

the second card, and make cohesion tests on both. When the difference between the two sets is 30 per cent or more, do not soak the silk, but oil it. Silks that lose only 10 per cent of cohesion after wetting give better results when soaked. As these lots usually have hard gums, they can be rubbed out when the silk is wet and the silk then hung up and dried. The winding will be greatly improved without affecting the weaving results.

Third, mechanical imperfections in the loom (cut reeds, harnesses, etc.).

Fourth, too humid air conditions during the dog days, which caused the soft-natured lots to loose cohesion. This was particularly noticeable on silks that stood a few days owing to the absence of a weaver.

Fifth, improper treatment in soaking, temperature too high, or an unsuitable emulsion.

Sixth, an excessive number of very fine threads and cleanness defects.

Studying Cohesion

To those interested in the study of cohesion, I suggest the following procedure:

1. Select samples of smooth and rough silks by the following method: Take a small skein of silk and find the absolute dry weight. Ignite the skein in a crucible for about 5 hours until all the black carbon disappears and only a white residue remains. Weigh this residue and determine the percentage of it by comparison with the absolute dry weight. This residue amounts to from ¼ to 2 per cent, and is composed principally of lime and magnesia.

2. Make a square frame of wood, similar to a drum, without top or bottom, and stretch a 225-m. sizing skein across it drum tight. Rub the skein with a ¼-in. diameter steel rod about 12 in. long. Rough silks containing mud, lime, and magnesia give a screeching sound when rubbed. Smooth silks having very little foreign substances in the gum give off little or no screech.

3. Test the cohesion on both kinds of machines, and note the difference between the rough and smooth silks.

4. Oil the samples and observe the difference in the results before and after.

Does cohesion also indicate the innate qualities of raw silk? Rosenzweig finds that it does, and he has been quite persistent throughout all his studies during the last 16 years as to the value of the quality. We find ourselves in agreement with him, as all our studies show that silk high in cohesion is always high in the physical characteristics, strength, and elasticity. Our researches show, however, that cohesion alone cannot be used to measure the innate qualities, for sometimes the cohesion is high in the cocoon fibers but only medium on the reeled thread because of faulty reeling methods or carelessness in reeling.

Temperature and Croisure Tests

W. F. Edwards, in *Silk*, 1923, gives a series of tests showing the influence of the temperature of the water and the length of the croisure on the cohesion of silk. He states that:

"Threads were made under varied conditions of temperature in the basins and in the length of the croisure. The threads were all of six cocoons and the drying on the reel was under practically the same conditions in all cases. After the threads were thoroughly dried (after standing 2 weeks) cards were made from different portions of the threads and the cohesion test applied in the usual way with the results shown in the accompanying tables. It should be observed that the length of the croisure has a marked influence on the cohesion in both cases, and that where

Strokes on the Cohesion Machine

	9½-in. croisure	4-in. croisure			½-in. croisure		
	2,147	988	1,005	1,272	773	584	800
	2,438	924	993	1,028	731	555	790
	1,205	866	850	910	681	538	774
	1,105	700	733	392	619	497	756
	1,013	741	631	389	504	450	666
Average,	1,581	843	842	798	661	524	797
Total average,	1,581	...	...	827	...	660	

the cocoons were held at 60 instead of 90° C. the effect was more noticeable on the ½-in. croisure. The three columns under 4-in. croisure represent silks made on three different days; the first column represents the silk made on the same day that the 9½-in. croisure silk was made.

Cocoons were held in the first basin at 100° C. for 15 min., then transferred to the second basin and held at 90° C. during the reeling operation.

STROKES ON THE COHESION MACHINE

	9½-in. croisure	4-in. croisure			½-in. croisure		
	1,863	1,070	1,037	1,003	761	352	641
	1,591	960	1,021	864	624	337	568
	1,466	937	1,003	770	562	328	566
	1,287	929	905	550	520	310	561
	1,204	800	890	489	468	307	509
Average,	1,482	940	971	735	587	326	572
Total average,	1,482	.....	882	.....	...	495	

Cocoons were held in the first basin at 100° C. for 15 min., then transferred to the second basin and held at 60° C. during the reeling operation.

Experience shows that it is easy to decide on how to dispose of silk that is strong or weak, but on silk that is neither strong nor weak one needs another measureable characteristic of the physical properties *viz.*, cohesion to check against the strength value so as to decide what each lot of silk is suitable for. The bulk of the silk produced is of medium grade in each of its qualities, and, as one cannot always get the best which is easy to select, one must take enough measurements of the various characteristics of the intermediate grades so as to use the best available at a price promising economical manufacturing of a specific product.

EVENNESS IN RAW SILK

Raw silk is irregular or uneven in size on account of the natural variation in the size of the silk filaments produced by

the silk worm. While careful reeling reduces this variation to a considerable degree, a raw silk thread does not possess the same degree of uniformity that is characteristic of a rayon thread or that is shown by a drawn or spun yarn, like cotton.

The denier of a raw silk, therefore, is always expressed in three numbers, as 13-14-15—marked 13/15 denier. The 13/15 average size, according to the raw silk reeler, may come within the limits of 13½ and 14½ deniers.

An abstract from a report published by the Imperial Sericultural Experimental Station shows the following variations in the denier size of different classes of cocoons:

	Finest	Medium	Coarsest
Italian high-grade yellow	2.29	2.90	3.24
Italian medium-grade yellow	2.22	3.00	3.59
French high-grade white	2.50	3.07	3.97
French medium-grade white	2.17	2.92	3.84
Shanghi high-grade white	1.57	1.97	2.01
Shanghai medium-grade yellow	1.60	2.09	2.33
Canton high-grade white	1.34	1.67	1.74
Canton medium-grade white	1.52	1.84	2.11
Japanese high-grade floating system	2.37	3.13	3.38
Japanese high-grade sinking system	2.11	2.76	3.36
Japanese medium-grade A white	2.19	2.41	3.12
Japanese medium-grade B white	1.97	2.50	3.31

Unevenness in the reeled thread is a condition of degree, number, and length of uneven threads. There is a general agreement among experienced users of raw silk that short lengths of threads within 30 per cent of the average size under or over (on a 13/15 size, those threads over 10 and under 18 denier) even up in two or more threads and produce an even product. Studies on the degree of evenness will then be confined to the threads within 30 per cent under and over the average size.

The Raw Silk Classification Committee in 1926 divided the uneven threads into five classes as follows:

1. Weak threads are those which break at 25 g. regardless of their size.

2. Very fine threads are those which break 50 per cent below the average strength of the thread.

3. Fine threads are those which break 30 per cent below the average strength of the thread under test.

4. Coarse threads are those which break 30 per cent above the average strength of the raw silk under test.

5. Very coarse threads are those which break 50 per cent above the average strength of the raw silk under test.

Number of Uneven Threads

A 20-yr. study of the number of uneven threads that appear in the different grades of raw silk shows that it varies greatly during the same season between different chops of the same grade and also between different seasons.

A radical change was found in the spring of 1922 when the coarse and very coarse threads quadrupled in number, due, I am told, to an endeavor to reduce the very fine threads, increase the production of the reeling girls, and reduce the cost of reeling.

In the sixth column of the following table the maximum number of all kinds of evenness defects that may be expected in 30,000 yd. of each of the six grades adopted by the Raw Silk Classification Committee in their 1926 report is given. The numbers in columns 2, 3, 4 and 5 are by the writer and represent the average number of each kind that may be expected in each grade.

Number of Evenness Defects

Grade	Very fine	Fine	Coarse	Very coarse	Total
XXX	..	6	4	..	10
Grand XX	..	10	10	..	20
Crack XX	1	12	15	2	30
XX	3	17	12	8	40
X	4	17	23	11	55
1	4	16	30	20	70

The lengths of the uneven threads in the best grades of raw silk, or those threads under 10 denier and over 18 denier on 13/15

size, range from 1/2 yd. to 50 yd., and average about 10 yd. On the lower grades they range from 1/2 yd. to 150 yd. and average about 20 yd. In the best grades of 13/15 size we find sizing skeins that weigh 11 deniers and others that weigh 17 deniers, but we do not find that the total length of the sizing skeins, 450 m., is of size 11 or 17; but these often show quite a variation in sizes, finer or coarser, than the average.

In practice, silk is reeled to average size. To get the average size on a skein of 450 m., the reeler must limit the length of the threads under 11 and over 17; and, as these average up as stated above, experience shows that we need not consider the length of the uneven thread in classifying evenness, but only the degree and number. (The sizing test skeins show the long lengths of fine and coarse threads.)

Silk Required for Tests

We find that the amount of silk required to represent a bale is 20 skeins drawn from 20 different books or part of a bale. To represent a lot of bales we find that two bales out of five, or three bales out of ten, must be tested.

We find that the yardage to be taken from the skeins to be tested varies according to the number of defects found in the silk. The greater the number of defects, the closer they are together and the less amount of silk required; the less the number of defects, the farther they are apart and the greater the length required to get results within half a grade on different tests from the same bale.

The variation one may expect when testing less than 30,000 yd., is shown by the following analysis of 25 tests made recently in which the same tests made on 30,000 yd. were divided into 10,000 and 20,000 yd. These tests were taken as they came on Crack XX and Grand XX and can easily be duplicated as far as the variation is concerned.

It will be observed that on the Crack XX and Grand XX, 28 per cent were alike on 10,000 yd.; and that on the 20,000 yd., 50 per cent were alike, or the same as the tests made on 30,000 yd.; but that 18 per cent of the tests on 20,000 yd. still varied

over 1 grade. On silk lower than Crack XX, 72 per cent were the same on 20,000 yd., and only 11 per cent varied more than 1 grade.

Evenness Tests Made on Crack XX and Grand XX

Variations Shown on 10,000 Yd.	Variations Shown on 20,000 Yd.
28 per cent of tests varied 1 per cent	50 per cent were alike
28 per cent of tests varied ½ grade	32 per cent varied ½ grade
26 per cent of tests varied 1 grade	14 per cent varied 1 grade
9 per cent of tests varied 1½ grades	2 per cent varied 1½ grades
5 per cent of tests varied 2 grades	2 per cent varied 2 grades
2 per cent of tests varied 2½ grades	
1 per cent of tests varied 3 grades	
1 per cent of tests varied 4 grades	
44 per cent varied over 1 grade	18 per cent varied over 1 grade

Evenness Tests Made on Silk under Crack XX

Variations Shown on 10,000 Yd.	Variaions Shown on 20,000 Yd.
38 per cent were alike	72 per cent were alike
36 per cent varied ½ grade	7 per cent varied ½ grade
18 per cent varied 1 grade	11 per cent varied 1 grade
9 per cent varied 1½ grades	
2 per cent varied 3 grades	
20 per cent varied over 1 grade	11 per cent varied over 1 grade

Years of experience show that tests made on 10,000 yd. vary so greatly that they are but a little better than a guess, and for engineering practice or for disposition purposes these are worthless.

The Raw Silk Classification Committee recommends 30,000 yd. as the standard for the gage test.

METHODS OF TESTING EVENNESS

The best-known methods of grading evenness are as follows:

First, the organoleptic methods used by the inspector who by the sense of sight and touch picks through a skein and counts

the evenness defects. This method is entirely subject to the inconsistencies of human judgment, and is dependent upon the skill and integrity of the inspector. I learn that this method is still extensively practiced in the smaller filatures. The extreme sizes, or the very fine and very coarse threads, are the principal defects found and considered in grading the evenness.

Second, the method of making calculations on the range and number of 225-meter sizing skeins above and below the average size. This method is no longer reliable for grading evenness, as the reelers have found a way to even up the fine and coarse thread and get a uniform average size. This method is gradually being abandoned by even those who have been its most ardent supporters.

The Raw Silk Classification Committee has unanimously agreed that evenness cannot be classified by the weight of 225-meter sizing skeins. Rosenzweig, in the September, 1926, issue of the *American Silk Journal*, recommends 200 skeins 18 meters long calculated according to the "theory of the least squares." He also appears to have abandoned the use of 225-meter skeins to grade evenness.

Seriplane Tests

Third, we find the black mirrors, Japanese drums, and seriplane, upon which the thread is wound with a uniform spacing and the evenness defects counted as they appear. We will consider only the seriplane test, for it is the most generally used.

When a raw silk thread is wound on the seriplane or any black card or mirror, one sees not only the long very fine, fine, coarse, and very coarse threads, but also the tolerable evenness defects—those threads of 10, 11, 12, 16, 17, and 18 deniers on a $^{13}/_{15}$ denier size.

An observer on the seriplane can generally classify the long very fine and very coarse threads correctly, but it has been found impossible always correctly to judge which are fine, coarse, and normal, as the density and shape of the thread cause misjudgment of the degree of evenness. This has been overcome by cutting the threads off the seriplane boards and deter-

mining the size by their breaking strength and by the weight and length of the evenness defects.

Short lengths of very fine, fine, coarse, and very coarse threads are rarely detected in a regular seriplane observation. The creeping of the threads on top of each other also hinders the observer in counting the short lengths of coarse and very coarse threads.

Experience shows that the seriplane method is entirely dependent on the judgment and honesty of the observer, and that an observer is easily deceived as to the degree of the evenness defects. However, we consider it the best method yet developed to picture evenness and an excellent and permanent contribution to laboratory equipment for the study of raw silk threads.

The seven-panel seriplane standards consist of seven arbitrary pictures of evenness adopted by the Raw Silk Classification Committee and issued by The Silk Association of America, Inc. They are not perspective views of evenness of the percentage values given on the standards, but are only a set of standard photographs used to match up with and estimate the evenness of raw silk wound on seriplane boards.

Variations of Standards

Unevenness does not naturally grade itself into seven evenness pictures. We know there are many varieties of each of the seven standards. Silk 80 per cent even may be a combination of 90, 80, and 70 per cent silks, or a number of other combinations. Any combination making an 80 per cent even silk, or making any other percentage, cannot be shown by a single panel of 500 yd., such as the standard photographs are made up of. The minimum amount of thread that can be used to show a perspective view of evenness is found to be 5,000 yd.—10 seriplane panels.

The studies in our laboratory show that no attempt is made to score the short lengths of very fine, fine, coarse, and very coarse threads which we find very essential in selecting silk for sheer products. Very few panels are found to match exactly

with the standards, and the observer must depend upon his judgment as to which one it matches up best with. We find that counting the evenness defects on the seriplane and measuring the size by a breaking test are more reliable than classifying by the seven-panel standard.

The Gage Test

The gage test depends upon the following characteristics of the thread and reeling methods to catch the uneven threads:

First, it depends partly upon the tension on the thread, caused by the speed of the thread over the tension board and through the ½-in. thick gage, to break down the very fine threads. When a break occurs, both sides of the break are tested on a scale for size, and all evenness defects found are scored.

Second, it depends on the major and minor cleanness defects that catch in the gage and break down the thread. In reeling the cocoons, when the thread changes from normal to fine and is brought back to size by the operator who casts in fresh cocoons, a hump is formed on the thread. This hump is called a *bad cast,* and, as this is larger than the slot in the gage, it catches and breaks down the thread. On one side of the hump is a fine thread, on the other side may be a normal or an uneven thread. As the fine thread has passed through the gage and on to the reel, the operator must test the end on the reel side for size, and must score not only the bad cast but also the fine end before she ties it up.

Third, it frequently happens that a very coarse thread follows a fine thread and the thread is broken down by a cleanness defect. In that case, the cleanness defect is scored, both sides of the cleanness defect are tested for evenness defects, and one or both are scored as found.

Fourth, the smallest raw knots also catch and break down the thread. The broken ends on both sides of the knot are tested for size and are scored as found.

Fifth, the very coarse threads choke up in the gages and break down the threads. Both sides of the break are tested for evenness defects.

As careless reeling causes uneven threads and also cleanness defects, and as the reeler's aim is to maintain average size by frequently casting in two and three cocoons at a time, we find that the thread defects are so nearly related to the evenness defects that very few fine and coarse threads pass through the gage without being scored.

SAMPLING

Can a sample book be drawn from a bale and the evenness of a 10-bale lot be determined from it? The following tests on 190 bales of Grand XX show the evenness value on a sample book as compared with the average on two bales. On the sample book 20 skeins were sampled, and 30,000 yd. were tested; on the two bales, 40 skeins were drawn from 20 different books of each bale, and 30,000 yd. were tested from each 20 skeins.

Number of bales	Evenness grade by sample book	Evenness grade, average of two bales
70	XX	XX
20	XX	Crack XX
20	Crack XX	XX
30	Crack XX	Crack XX
10	Crack XX	Grand XX
10	Grand XX	Grand XX
10	Grand XX	Grand XX
20	Grand XX	Crack XX

These tests are typical examples of the results obtained on sample books, and show that tests on sample books give very uncertain results.

Application of Gage Test

Extensive researches were made in the laboratory, in throwing, and in the knitting of hosiery and fabrics in the plant of Julius Kayser & Co., to determine the disposition values,

operating costs, reliability, and limits of the gage test. A part of these studies are presented here by the courtesy of Julius Kayser & Co.

Twenty skeins of $^{13}/_{15}$ denier raw silk were selected from 20 different books of a bale. On the gage reel 30,000 yd. were tested according to the standard method.

The silk left over from the test was knitted into tricot fabric—single thread, two beams—and every precaution was taken to get the "quality," or length of loop, uniform.

Classification	Thread defects (evenness)	Total uneven threads in fabric	Fabric inspection (number of fine and coarse streaks)
XXX	10	11	14
Grand XX	20	19	31
Crack XX	30	34	41
XX	40	47	53
X	55	56	79
1	70	90	101
2	over 70	116	191

In the first column are the grade names adopted by the Raw Silk Classification Committee. In the second column are the thread defects given by the same body. In the third column are the number of uneven threads found in the test as close to the grade as we could select. In the fourth column are recorded the number of fine and coarse streaks across the fabric. The fabric was made up of 1,000 threads in the warp. Figure 5 illustrates samples showing the evenness of fabrics from each grade.

A close study of the samples and the evenness rating showed consistent results and proved that grading evenness by the number of defects and degrees, regardless of length, gives relative results in evenness in tricot fabric.

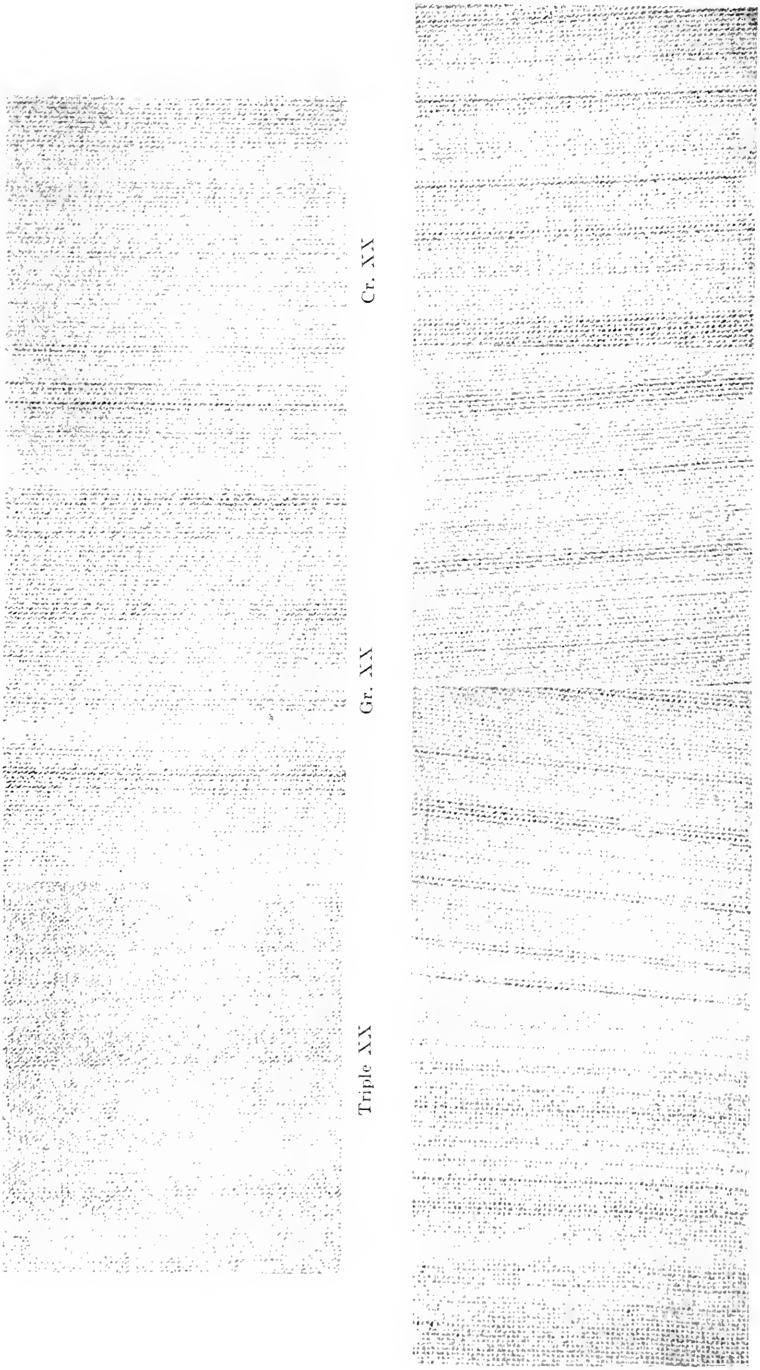


FIG. 5.—Prints of tricot fabric showing seven levels of evenness.

Tests on Hosiery

Twenty pounds of silk were taken and sorted skein for skein into two lots, thrown into 8-thread and 10-thread hosiery tram, dyed black, and knitted into ingrain stockings. The gage test was made on average size and showed the following evenness defects on 30,000 yd. Size of raw silk was $^{13}\!/_{15}$ denier.

	Threads
Very fine (under 7 deniers)	3
Fine (under 10 deniers)	8
Coarse (over 18 deniers)	35
Very coarse (over 21 deniers)	34
	80

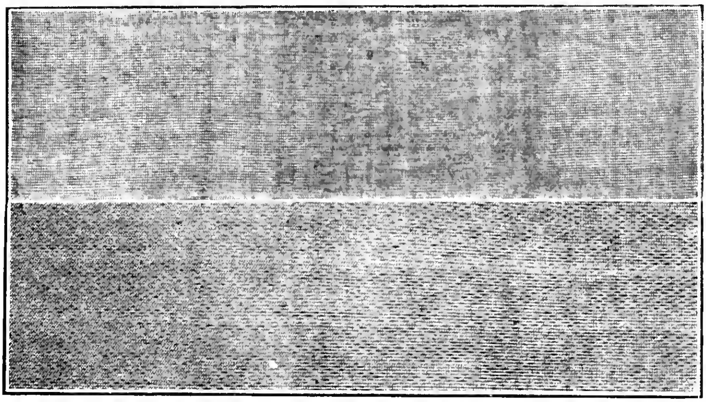


Fig. 6.

The stockings were all inspected before being seamed, in the boot only, and sorted into three classes as follows:

First choice—cloudy, or with slight light and dark streaks.

Second choice—medium light and dark streaks showing.

Third choice—decided light and dark streaks showing.

Figure 6 shows representative fabrics of both first and third choice.

The inspection of the 8-thread stockings showed:

	Percentage
First choice	28
Second choice	47
Third choice	25

The inspection of the 10-thread stockings showed:

	Percentage
First choice	47
Second choice	34
Third choice	19

The evening up effect on the 10-thread hosiery showed an increase of 19 per cent in the number of firsts, and a reduction of 6 per cent in the number of thirds. Ninety threads were raveled from one of the third-choice stockings. The normal part weighed 133 deniers and the decided dark streak weighed 153 deniers, or a variation almost equal to that between a 10- and 12-thread, 13/15 raw size.

The following table shows a summary of eight lots all knit from the same 20 skeins tested, dyed black, and knit ingrain, giving the relation of the very coarse threads to the third-choice stockings. (The very coarse ranged from 1/2 to 50 yd. in length.)

Thread	Very coarse in 30,000 yd.	Number of third-choice stockings, percentage
6	3	
6	44	39
6	40	25
6	28	21
6	12	16
8	34	25
10	34	19
10	77	41

Three-thread stockings knit ingrain from the same 20 skeins, when tested for evenness, gave the following results:

Evenness defects						Hosiery inspection			
Grade bought	Very fine	Fine	Coarse	Very coarse	Even, percentage	Color of hosiery	First class, percentage	Second class, percentage	Third class, percentage
Special XX.....	1	4	20	8	63	Circassian..	20	35	45
Special XX.....	1	2	5	1	91	Black......	77	24	
Special XX.....	..	2	7	2	86	Silver......	60	33	7

As the colors were not the same, a strict relation between the different lots was impossible. The tests show, however—without a question of doubt—that the short, very coarse threads were responsible for the thirds, and that the fine and coarse threads must be limited to under 7 on 30,000 yds., if one hopes to get somewhere near 80 per cent of firsts on hosiery knit ingrain.

The light streaks in stockings were very few, verifying the relation in number of the fine ends to the coarse in the raw silk test, and was not a case of passing the fine in the test.

Six-thread tram was dyed black and knit ingrain. Stockings were knit from the same 20 skeins tested.

Grade bought	Very fine	Fine	Coarse	Very coarse	Evenness, percentage	First choice	Second choice	Third choice
Special XX................	..	1	5	2	89	75	25	
Crack XX................	..	3	31	44	29	16	45	39
Italian X. C................	1	6	42	40	29	20	55	25
Crack XX................	2	4	32	28	37	32	47	21
Italian G. X................	..	4	38	12	56	51	39	16

This table shows that the coarse and very coarse threads still do not even up. A study of the firsts and the percentage of evenness shows a fairly consistent relation between the two; but a close study of all the factors entering into consideration shows that a closer relation can be obtained by penalizing the very coarse by three times instead of twice, as was done to arrive at the percentage rating.

Other Studies on Evenness

A great variety of other researches were made to study the evenness problem as it applies to raw silk, the using of raw silk in hosiery, and to determine the following information:

First, must a finer gage be used so as to get all the fine and coarse threads in the silk tested to rate evenness, or does the test made at the average size give constant results, a true relation to evenness in the product, and results that can be relied upon in buying and disposing of raw silk? The experiments proved conclusively that evenness tests made on the gage test at average size answer all practical purposes, and that there is a fairly consistent relation between the evenness percentage and the unevenness in hosiery and fabric; but to meet criticism it appears desirable to use the gage 20 per cent finer than average size. The former table must then be increased correspondently.

Second, must the very fine and very coarse threads be penalized alike to get an evenness rating, and to allocate them into a grade that will show comparative evenness results in hosiery and fabric? The results of our researches showed that the very fine and very coarse threads should be penalized three times, so as to get consistent comparisons and allocate the evenness defects as one number into a grade. Our finding, however, was that a strict relation is impossible, and that one must first group the evenness of the product, then group the evenness defects, and finally compare a group of evenness defects with a group of evenness of the product.

Unevenness More Pronounced

Third, is unevenness more pronounced in the product when there are about an equal number of very fine and very coarse threads than when the coarse and very coarse threads predominate? Since the spring of 1922, the number of very fine threads in the $^{13}/_{15}$ size has decreased about 50 per cent, but the coarse and very coarse threads have quadrupled in number. The average size, as a result, has increased about $^{4}/_{10}$ denier. What result has this had on hosiery and knit fabric as far as evenness

is concerned, and what has been the effect on the operating cost in throwing and knitting?

Unevenness was found to be more pronounced when the evenness defects were about equally divided between very fine and very coarse threads than when they were mostly above or below the average, or when either side predominated. Further observation showed that as the short lengths of coarse and very coarse threads do not even up, as has been clearly demonstrated by the tests, they have been the cause of a great amount of streaked hosiery in the last four years. The smaller number of very fine threads has reduced the throwing costs, as there were fewer breaks.

The reduction in the very fine threads has not been noticeable in the coarser sizes; in weaving the coarser sizes of single thread in the gum, the coarse and very coarse threads do not show in the fabric; while in knitting single thread in the gum, the coarse and very coarse show every unevenness defect.

Fourth, is fabric when made from 40 per cent unevenness and sold as a Grand XX any evener than when sold as a Best 1/Ex? Experience shows that silk sold as Grand XX often varies in evenness from Grand XX to Extra, and that the chop and grading of the primary market are therefore not dependable. If the percentage is based on a fixed grouping of a range in number of evenness defects, and the extremes are penalized by a multiple factor of three, then the percentage always represents the same grade of evenness regardless of for what grade the silk is bought.

Fifth, what consideration must one give to uniformity, and how can it be determined? The gage test is generally made on 30,000 yd., with each 10,000 yd. scored separately. The degree of uniformity is judged by the range in the number of defects on each 10,000 yd. If one 10,000 yd. shows 50 per cent evenness, and another 10,000 yd. shows 70 per cent evenness, the unevenness on the fabric is more pronounced because of the greater contrast between the wide streaks of the even and uneven threads than if one 10,000 yd. is 50 per cent uneven and the other is 55 per cent uneven. On hosiery where but a small amount of silk is used in one stocking, the number of

firsts is governed by the average percentage, provided the very coarse and very fine threads are penalized and the short and long lengths of evenness defects are counted.

As there is constant and persistent criticism that the gages pass, and do not score, the fine and very fine threads, the light streaks in fabric and hosiery caused by fine and very fine threads were made a subject of long and intensive study to determine their relation to the number scored by the gage test so as to decide definitely whether the criticism was sustained.

Agreement of Results

The study showed that the gage test made on medium grade silk on 30,000 yd. repeated itself within half a grade on repeated tests on 20 skeins from 20 books of the same bale when the silk was all reeled at the same filature.

We did not find that the number of very fine, fine, coarse, or very coarse threads are the same. We did find that if one test has many fine and very fine, the other tests also will show the same general condition; and that if the fine and very fine threads predominate in one test, they will also predominate in another. The same holds true regarding the coarse and very coarse threads. In examining the fabric one finds that when the coarse and very coarse predominate in the gage test, then coarse and very coarse streaks predominate in the fabric. The same holds true also of the fine and very fine. While it is possible by the gage test to grade evenness as close as 1 per cent, it is impossible to apply its use in hosiery or fabric in less than 10 per cent, as the elimination of very fine threads in the preliminary departments and the evening-up factor on multiple threads extends the scope of application to a difference of about 100 in the evenness defects in 300,000 yd., or called about 10 per cent.

In other words, one cannot notice a difference, by visual inspection, between fabrics knit from 50 per cent and 55 per cent silks; but when one compares a 50 per cent silk with a 60 per cent silk the difference is noticeable, for the number of evenness defects between 50 and 60 per cent is about 100 defects on 300,000 yd.

Before studying the various methods now used to measure and classify evenness, let us consider the variation that must be tolerated in a test of this kind and judge it by comparison with tolerances found in other raw silk tests. Technically speaking, all tests on raw silk are subject to variations, due to the variation in the different qualities; but, as the scope of application is not a matter of fine application, reasonable variations are negligible.

The international standard test for average size calls for 30 450-meter skeins. Repeated tests on the same bales sometimes give two different sizes. When 200 sizing skeins of 450 meters, or 20 skeins of 4,500 meters are used, then the results are found to be within the same size; yet 30 450-meter sizing skeins are accepted internationally as a standard, and are quite frequently used. Experienced technicians know that the boil-off and conditioning tests are not absolutely repeatable; in practice we accept the results of the tests, when the tests are made the same way, as accurate enough for all practical purposes.

In classifying evenness, we have aimed to keep within a variation of half a grade, or about 3 per cent. In actual practice we find that repeated tests on the same bale generally are within a range of half a grade when using 30,000 yd. on medium grades of evenness.

On the higher grades we find it necessary to use from 40,000 to 60,000 yd. to get results within the range specified.

Criticism of Gage Test

The criticisms of the gage test are principally as follows:

First, that the fine and very fine threads pass through the gages and are not counted, and that evenness therefore cannot be classified. Where I have had the privilege of following up this criticism, I have found that the gages were opened and reset to twice the opening specified for their use. I agree that under such careless conditions the very fine and fine threads will pass through and not be scored. The greatest amount of criticism comes from inspectors and importers; they say that

the gage test penalizes evenness too much, and that it scores too many fine and very fine threads.

Second, that different laboratories using the test do not agree within a grade upon the same sample. I regret to admit that this is a fact and that it is due to plain carelessness or lack of interest. Time and again we have taught operators how to make the gage test so that within three days' time they have duplicated our tests within the variation of the silk itself. However, just as soon as they have gone back to their own laboratory they have operated the test along the lines of least resistance and have ignored simple rules, with disagreements the inevitable result.

Our experience is that not only is the gage test falling down as far as agreement between different laboratories on the same silk is concerned, but that the users of the seriplane are having the same experience. These disagreements on both methods are largely due to deliberate actions on the part of inspectors, testers, and reelers, which are found to be as follows:

Different Grades Required

First, different silk products require different grades of evenness. This has brought about individual classification according to the requirements, regardless of a standard. The gradual increase in the number of evenness defects by the reelers has made it necessary for inspectors constantly to lower their standard of evenness to meet the best market classification.

Second, a number of laboratories have been opened by inspectors who have their own private methods of testing and disposition, and are not favorably disposed to any other standards. To their way of thinking, it discredits them to adopt another method.

Third, we receive skeins in Grand XX that are reeled evenly but that are so mixed up with unevenly reeled skeins in the filature that it is almost impossible to get silk even enough for sheer products.

Fourth, the unevenness has become so marked that silk sold for Grand XX varies four grades in evenness—from Grand XX to Extra. About one-third is found to be Grand XX, about

two-thirds Crack XX, and the balance XX and Extra. Other grades vary about the same. This indicates that four evenness standards prevail in the filature and primary market. We find that books in the same bale and that bales in the same lot of 10 bales often vary as much as three grades.

Fifth, even though this irregular condition exists, we find the most even silk in the highest market grade and the most uneven in the lowest grade.

The lack of proper assortment in the filature, the mixing of even with uneven books in the same bale, and the mixing of uneven bales with even bales in a lot of 5 or 10 bales, make it practically impossible to get results that represent a lot by testing only a few sample skeins or books on one seriplane board. (The Raw Silk Classification Committee recommends 20,000 yd. for a seriplane test, and 30,000 yd. for a gage test.)

Sixth, in practice the different standards prevailing in America work out about as follows:

A requires the most even silk reeled; he adopts as his standard the most even silk he can buy, and orders Grand XX.

B manufactures a lower grade or heavier product than A. He finds that the average grade of evenness is satisfactory, but as he requires silk high in its physical properties and wants to maintain operating efficiency, he adopts an evenness standard a grade lower than A so as to avoid many rejections; but to assure working qualities and physical properties he also buys Grand XX.

C manufactures a product where only the extremely fine and coarse threads cause defective fabric, and he adopts an evenness standard about two grades under A's; but, as he also wants to maintain plant efficiency, he too buys Grand XX.

This diversified requirement and practice has brought about a great demand for high-grade silk—a demand which the reeler is supplying by giving us four grades of evenness in Grand XX.

The present method of using different standards in America is responsible for the present unevenness of the Grand XX and Crack XX silks. This is temporarily working out to the advantage of the careless reeler and others who profit by it at the expense of the reelers of high-grade silk and the manu-

facturers of high-class products who suffer unnecessary losses through increased seconds.

This chaotic condition emphasizes the need of getting together, pooling our methods and researches, and developing an international standard. We reluctantly admit that after years of effort, gage users and seriplane users do not stick to a standard. We have no means now of controlling different laboratories. Indifference and only passive cooperation is encountered in attempts at getting together on the gage and seriplane. Permit me to give an illustration showing what is happening in actual practice.

C sent in four sample bales of Grand XX and Crack XX for test. The gage test showed the Grand XX as 63 per cent even and the Crack XX as 37 per cent even. This is about three grades difference in evenness. We wound the samples on the seriplane and called in the inspector representing the seller, asking him to classify the silk by his method. He used the seven-panel seriplane standards and classified both silks as 80 per cent even.

A general observation of both samples on the boards caused the inspector to say that there was quite a difference between the evenness of the two silks; but he did not agree that the difference was three grades as shown by the gage test.

In explanation of the above classification by the experienced observer with the seven-panel standards, it was noticed that the inspector was indifferent in matching up the silk with the standard panels, as he wanted to get a result that confirmed the grade given the silk when it was sent in. To do this he was liberal in judging the percentage of the panels under observation. The final result, however, proved higher than he anticipated on the Crack XX, and he had no opportunity of changing this to meet his wishes.

The point I desire to make is this: If we cannot control these conditions in America, who can control the reelers and inspectors in the primary market and prevent them from valuing the panels on a high level, particularly when it is a matter of a 10 to 20 cts. per pound gain or loss and sometimes means a business success or failure?

Many other incidents might be cited to show that the only hope of an international standard will be found in an automatic machine that records evenness and cleanness defects independent of the operator, and gives the results based on the number and degree of evenness defects.

An automatic evenness-testing machine was demonstrated at the Philadelphia Sesqui-centennial Exhibition and a description of it was given in the August, 1926, *American Silk Journal.* It is called the "Tanahashes Evenness Graph" and automatically tests and records the evenness on every 10 thousand yards of thread.

This machine penalizes the very coarse and very fine threads, registers all the evenness defects, and gives some promise of showing the way to the solution of an international problem provided it is improved so as to test at least 10 bobbins at a time (30,000 yd. all told) within a reasonable length of time. We find that if the thread is tested for evenness every 20 yd., it will answer all practical purposes. It will also be necessary to invent an automatic machine to test cleanness to be used in connection with the evenness graph.

It affords me pleasure to close these articles on evenness with a statement by the general superintendent of Julius Kayser & Co., Mr. R. K. Boadwee, as follows:

I desire to add to what has been stated by Mr. Seem that the gage test is giving satisfactory results in selecting raw silk for our various products, and that the object of encouraging the publication of these articles and of giving a part of our extensive researches on raw silk qualities and their application to knit fabric and hosiery is to show the seriousness of the evenness defects, the uncertainty of the present market grading, and the facts upon which an international classification of evenness must be based. It is hoped thereby to encourage constructive work for an international standard.

We have not the slightest desire to reflect upon the pioneer work done to bring the classification before the trade; on the other hand, we desire to commend and praise those who have given their time and efforts to keep the subject before the public and bring about the present state of its development.

Our experience proves that while the gage and seriplane tests are perfectly satisfactory for our work, and while we recommend them for

private practice, we are thoroughly convinced that neither method is suitable for an international standard, and we feel that a test that automatically measures and records evenness and cleanness defects is necessary.

We further believe that work toward an international standard for the classification of raw silk has arrived at a stage where we can hasten the final development of such a standard by engaging unbiased technicians to quicken the general interest and promote a more ready response to the adoption of such a standard.

CLEANNESS DEFECTS IN SILK THREAD THAT INTERFERE WITH OPERATIONS AND LOWER QUALITY

The cleanness defects are divided into three classes by the Raw Silk Classification Committee; *viz.*, major, minor, and miscellaneous defects, as follows: Major defects include waste, slugs long or large, bad casts, long knots, and very long knots. Minor defects include nibs, corkscrews, heavy corkscrews, hairiness (split threads), loops, long loops, and neatness. Miscellaneous defects include lousiness, raw knots, and double ends.

The average number of each defect that may be expected in each grade the author finds are as given in the following table:

Cleanness Defects

Grade	Name	Defects per 30,000 yd. Number of each kind	R. S. C. C. standard
XXX	Major:		
	Waste	2	
	Very large slugs		
	Very long knots		
	Very large loops	1	
	Split threads		
	Small slugs	1	
	Bad casts	1	
	Total major	5	5
	Minor:		
	Nibs	40	
	Loops	30	
	Long knots		
	Corkscrews	15	
	Total minor	85	85
Grand XX			
	Major:		
	Waste	1	
	Very large slugs	1	
	Very long knots	1	
	Very large loops	1	
	Split threads	1	
	Small slugs	3	
	Bad casts	2	
	Total major	10	10

CLEANNESS DEFECTS.—(*Continued*)

Grade	Name	Defects per 30,000 yd.	
		Number of each kind	R. S. C. C. standard
	Minor:		
	Nibs	35	
	Loops	40	
	Long knots	10	
	Corkscrews	25	
	Total minor	110	110
Crack XX			
	Major:		
	Waste	2	
	Very long slugs	1	
	Very long knots	1	
	Very large loops	2	
	Split threads	1	
	Small slugs	5	
	Bad casts	3	
	Total major	15	15
	Minor:		
	Nibs	45	
	Loops	55	
	Long knots	10	
	Corkscrews	25	
	Total minor	135	135
XX			
	Major:		
	Waste	2	
	Very large slugs	1	
	Very long knots	1	
	Very large loops	3	
	Split threads	1	
	Small slugs	8	
	Bad casts	4	
	Total major	20	20

CLEANNESS DEFECTS.—(*Continued*)

Grade	Name	Defects per 30,000 yd. Number of each kind	R. S. C. C. standard
	Minor:		
	Nibs	60	
	Loops	80	
	Long knots	10	
	Corkscrews	25	
		175	175
X			
	Major:		
	Waste	4	
	Very large slugs	2	
	Very long knots	2	
	Very large loops	4	
	Split threads	2	
	Small slugs	10	
	Bad casts	6	
	Total major	30	30
	Minor:		
	Nibs	85	
	Loops	100	
	Long knots	10	
	Corkscrews	30	
	Total minor	225	225

CLEANNESS DEFECTS.—(*Continued*)

Grade	Name	Defects per 30,000 yd.	
		Number of each kind	R. S. C. C. standard
No. 1	Major:		
	Waste	6	
	Very long slugs	3	
	Very long knots	3	
	Very large loops	6	
	Split threads	3	
	Small slugs	20	
	Bad casts	7	
	Total major	48	48
	Minor:		
	Nibs	110	
	Loops	150	
	Long knots	10	
	Corkscrews	30	
	Total minor	300	300

The Raw Silk Classification Committee standard, as given in the table, is the maximum number of all kinds that is permissible in each grade. The various defects are shown in Fig. 7.

The thread defects that generally affect operations are weak threads, very fine threads, very large slugs, very large loops, waste, very long knots, and split threads. The thread defects that affect the quality of the product are principally fine, coarse, and very coarse threads; slugs; bad casts; nibs; and hairiness (also called neatness and lousiness).

The weak and very fine threads and the major defects are mostly removed in throwing and in winding, warping, and quilling, and do not affect the quality of the product as much as the very numerous smaller defects.

MAJOR DEFECTS

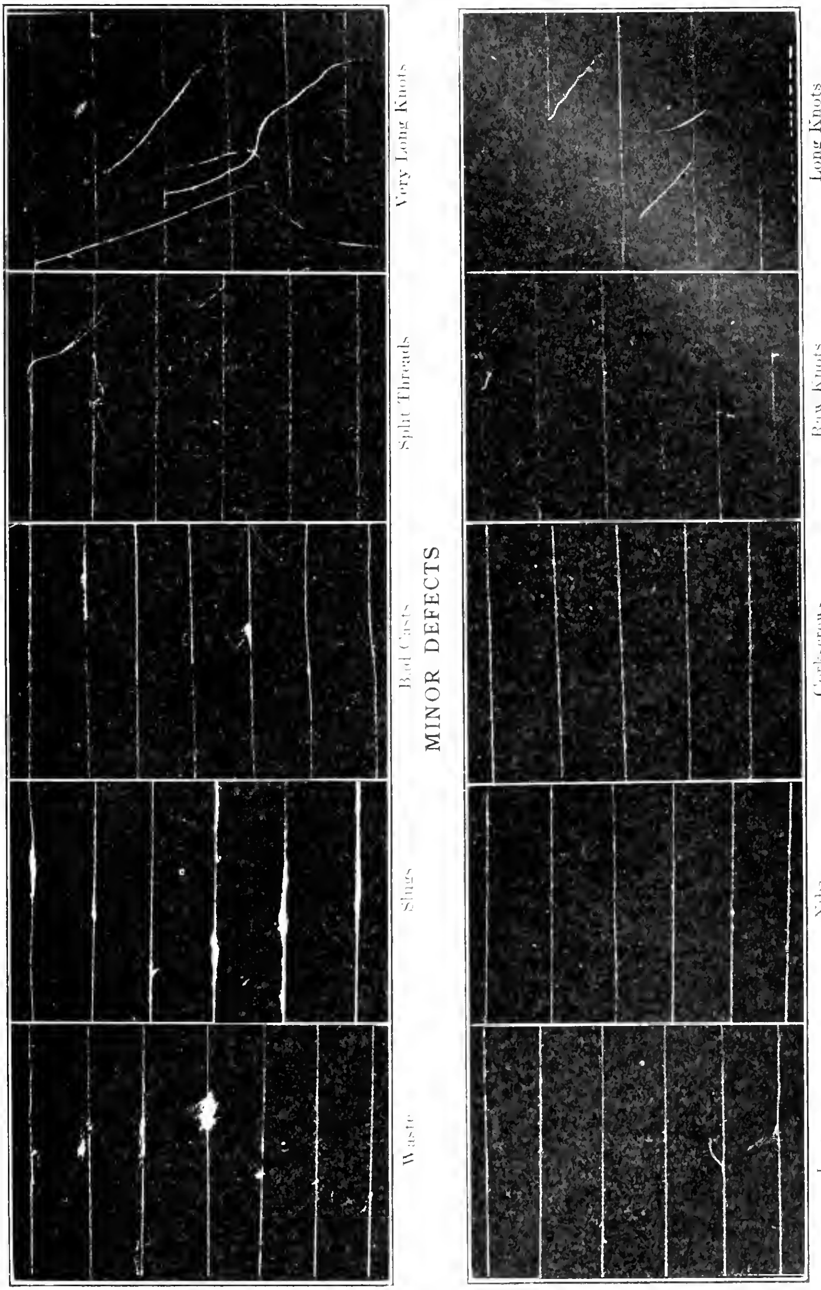


Fig. 7.

DISPOSITION OF RAW SILK OR ASSIGNMENT OF RAW SILK TO SPECIFIC PRODUCTS

Under the term "disposition" we shall study in a general way the assignment of raw silk to specific products. This requires the following information to perform the work efficiently: *First*, a specific knowledge of the relative value of each quality comprising a grade of raw silk; a practical means of measuring each quality and determining in what grade of silk it may be found. *Second*, a general knowledge of the peculiar characteristics of each class of thread and the preparation and throwing of it. *Third*, at least general information on the peculiar characteristics of each class of woven and knit fabric and the manufacturing operations. *Fourth*, a general knowledge of the essential qualities of the finished product.

The demands, for sheer and transparent products, speed of machinery, and high labor rates calls for the highest grades of raw silk that can be reeled to produce quality at a reasonable profit. As the supply of the highest grades does not nearly meet the demand, our problem generally resolves itself into selecting the best silk obtainable or one that will produce a salable product at the minimum cost of raw stock and manufacturing operations.

Efficiency of Price

The raw stock may be the cheapest in the market and thus show the highest efficiency of price, but the manufacturing costs and waste may be so high and the product so low in quality that it can only be sold as a second grade at a loss, and the end or net efficiency of the business will thus be low.

Under the efficiency of price we must consider the financial ability to contract and buy ahead in a low market, the experience to judge the trend of the market and business conditions influencing it and to choose the most favorable buying time.

During the months of June, July, and August, we receive raw silk reeled from the remnant of the closing season's cocoon crop, which always supplies a lower grade of raw silk. Frequently the price is lowered during this period to stimulate

buying and move out the old stock. As stated in a former chapter on evenness, as a rule, about one-third of the silk offered in each grade is up to grade, and about two-thirds is one or more grades under in evenness. This demonstrates the need of knowing the quality of the silk required for the product and what is offered against a sale, and the need of buying quality and not name and crop.

Buying Quality

How can one determine whether the silk offered against a sale is worth the price? We have no means of controlling the price or quality. The price is somewhat controlled by the supply and demand. Occasional efforts are made by interested parties to stabilize the price, which is a condition eagerly longed for in the American market.

The fact that a grade is a combination of four major qualities of raw silk; that these qualities are not always of equal value, even on the highest grades; that certain products do not require that all of the qualities be of the highest value; and that such silk are entirely suitable for other products, has brought about the practice of permitting the buyer to test the silk offered against a sale and accept or reject it as his experience may direct.

These conditions bring about such a situation that in order that the buyer can secure the end or net efficiency or the efficiency of price of raw silk, manufacturing costs, and quality, he or the one passing on the silk must not only have the knowledge already named in the four items in the opening of the chapter, but must also be able to estimate from the raw silk tests the "plus costs."

Plus Costs

By "plus costs" are meant the costs above that estimated for a product when setting an advance selling price.

The "plus costs" may be determined from the number of defects found in the silk by tests, if sufficient silk is sampled,

and their relation to operating costs, waste, and quality of product, as will be explained later on.

It is not within the scope of this chapter to study all kinds of threads and products and specify what kind of silk to buy to produce a salable product economically, as that is so largely dependent on the policies of the house, the efficiency of the management, labor conditions, wages paid, and the quality of the product desired that no fixed rule can be given; besides, the average mill life of one man is too short to study fully the standard products, not to mention the new creations brought out each season. We can, however, study definite methods of procedure that are practically similar in all cases and then use common sense in the assignment. To give a practical demonstration as to how to arrive at the "plus costs" we will consider a raw weave product.

Weaving in Gum Single Thread

Raw silk to be suitable for raw weaving requires the following characteristics: *First,* it must have a good cohesion or compactness and must not readily open in the weaving operations. The degree of cohesion required depends on the warp construction, speed of the loom, and the clearance of the thread in the reed. The finer the reed and the higher the speed the better the cohesion required. *Second,* it must have good working qualities. The working qualities are affected by an open thread; by weak, very fine, and brittle threads; and by the major cleanness defects. *Third,* the thread should be smooth and lack unnecessary roughness. Evenness is not essential and only extremely fine and very coarse threads need be guarded against. Heavy corkscrews affect the quality.

The "plus costs" are determined as follows on winding and warping: The raw silk defects that affect winding are weakness, very fine threads, waste, loose ends, poor crossings, and hard gums. The raw silk defects that affect warping are weak, very fine, and brittle threads and major cleanness defects. The warping is also affected by excessive winding breaks if the winding bobbins are not back wound or redrawn. While the

general theory is that the winding eliminates all the defects and none pass on to the warper, in mill practice we find that when the winding breaks are high, the warping costs are also affected.

Frequently the manufacturers console themselves that as they pay a fixed rate for warping, the help absorb the increased breaks by speeding up, but that does not cover the waste and allowances.

The accompanying table, entitled "Winding and Warping Plus Costs," gives the "plus costs" in cents per pound and includes excessive operating costs and waste. The winding "plus costs" are determined from the winding count when the unsoaked silk is wound for tests. The warping "plus costs" are determined from the winding breaks and defects that affect warping. The actual "plus costs" must be determined from individual plant costs and based on the average of a number of lots. They require revision occasionally and adjustment to changes in methods and management. In practice, estimates based on such tables are found to average up closely with actual costs over a yearly period.

Winding and Warping Plus Costs

(Given in cents per pound)

(Figures are arbitrary and given only to assist study of method)

Grade	Winding breaks on 300,000 yd.	Winding plus costs	Total defects that affect warping	Warping plus costs	
				Bad winding	Raw silk defects
A........	Under 35	0	Under 60	1	0
B........	36/45	2	61/90	..	1
C........	46/55	3	91/120	..	2
D........	56/65	5½	121/150	1	3
E........	66/75	8½	151/180	2	4
F........	Over 75	12½	181+	3	6
G........					

WEAVING PLUS COSTS—I
(Due to defects in physical qualities)
(Figures are only arbitrary and given to assist study of method)

Grade	Strength		Brittleness		Cohesion	
	Grams per denier	Plus costs	Threads under 8 per cent elongation	Plus costs	Strokes	Plus costs
A.	4	. .	1	0	500	0
B.	4	. .	5	1	400	1
C.	4	. .	10	2	300	3
D.	3.8	. .	15	3	200	5
E.	3.15	1	20	4	150	7
F.	3.25	2	30	5	100	8

PHYSICAL QUALITIES

The physical qualities, as a rule, affect only the weaving operations. These qualities are strength, brittleness, and cohesion. (See the table entitled "Weaving Plus Costs—I.")

The raw silk defects that affect weaving operations are given in the table entitled "Weaving Plus Costs—II." The raw silk defects are given on 30,000 yd. (Only arbitrary "plus costs" are given for study of method.)

A summary of the three "plus costs" tables already referred to would show, all other things being equal, the "plus costs" on each grade of silk listed in the table entitled "Plus Costs on Each Grade."

This summary shows that Product X, if made from Grade A, all things being equal, would show a plus cost of 1 ct. per pound of raw silk; grade B, 6 cts.; grade C, 12 cts.; grade D, 20½ cts.; grade E, 29½ cts.; and grade F, 38½ cts.

Plus costs made for other products might show a very different result and indicate the kind of silk to buy to attain the desired results. If the defects always appeared together in

number and kind, one could determine the plus costs from the grade; but, as they rarely are alike in number and kind, it becomes necessary to compute each test separately.

WEAVING PLUS COSTS—II
(Due to raw silk defects)

Grade	Weak and very fine	Waste	Very large slugs	Very large knots	Very long loops	Split threads	Total	Plus costs	Total minor defects	Plus costs	Total plus costs
A.	..	2	..	..	1	..	3	1	85	..	1
B.	..	1	1	1	1	1	5	2	110	..	2
C.	1	2	1	1	2	1	8	3	135	1	4
D.	3	2	1	1	3	1	11	4	175	2	6
E.	4	4	2	2	4	2	18	5	225	3	8
F.	4	6	3	3	6	3	25	6	300	3	9
G.											

BETTER THAN GUESS WORK

It will probably appear to the practical manager that such plus costs will involve considerable labor for collecting the necessary data, and, to be of practical value, must cover a period of time and be based on averages. The tests must be large

PLUS COSTS ON EACH GRADE PRODUCT X

Grade	Winding + costs	Warping + costs	Weaving physical + costs	Weaving defects + costs	Total + costs
A.	0	0	..	1	1
B.	2	1	1	2	6
C.	3	2	3	4	12
D.	5½	4	5	6	20½
E.	8½	6	7	8	29½
F.	12½	9	8	9	38½

enough to represent the silk. The progressive manager will, however, recognize that it is just what he requires and just what someone in his organization is now trying to do by guessing. He guesses that the winding costs will be normal, high or low; that the warping and weaving will or will not be normal; and that the fabric will or will not be a first-class product.

This method is presented to show a better way than that of haphazard guess work; and experience proves it will approximate closely the average costs and prove correct enough in specific cases to be used as a much better guide than a guess in selecting and disposing of raw silk. If tables are first made on standard products, new styles can be closely estimated and afterwards corrected to represent actual costs.

Can the evenness grades given in the "defect test" be used in the assignment of raw silk to sheer hosiery and other products, and will the number of first-class hosiery be practically repeatable each time when made from the same grade? Yes, if the proper penalties are applied to the extreme sizes and the grading is corrected accordingly, as will be explained hereafter.

Considering Evenness

For our study we shall use 300,000 yd. as the basis of the number of evenness defects. This amount of silk will produce at least a dozen pairs of hosiery and about 5 yd. of fabric for inspection, and will give the active mill man a basis upon which to follow these studies. According to the Raw Silk Classification Committee rules, the following are the evenness defects for each grade on 300,000 yd.:

XXX	50 to 100
GR XX	101/200
CR XX	201/300
XX	301/400
X	401/500
No. 1	501/600
No. 2	Over 600 (601 to 2,000+)

Our researches, as given in the chapter on evenness, show that it is the extremely fine sizes that cause the light streaks

and the extremely coarse sizes that cause the dark streaks in the product. It is proved very clearly that a product made from a silk having about 50 uneven threads to a pound has decidedly less uneven streaks than one made from a silk having 200 uneven threads; but we do not find, the size being equal, that 70 uneven threads would show more uneven stockings than a silk having but 50 uneven threads. This is because of the evening up in multiple threads, different lengths of uneven threads, and covering factors; and because there are no means now available of accurately measuring the evenness of the finished product. It has been found, however, that where the difference in the number of the defects is 50, of the same size, or threads of different sizes are converted to a general or common level by penalizing the very fine and very coarse with a multiplying factor of 3, then a grade based on 50 evenness defects will establish a ratio of grade to the evenness of the product.

Two Actual Tests

We shall instance two actual tests of GR XX silk showing 150 defects each, size 13/15 denier.

Lot A	Weak threads	10 under 6 denier
	Very fine	20 6 to 7 denier
	Fine	50 8/10 denier
	Coarse	50 18/20 denier
	Very coarse	20 over 21 denier
	Total	150
Lot B	Weak threads	0
	Very fine	0
	Fine	30 8/10 denier
	Coarse	100 18/20 denier
	Very coarse	20 over 21 denier
	Total	150

Which is the most uneven silk and which will produce the most streaked four-thread black hosiery? If all of the other threads in Lot A were even (I mean the rest of the silk used in

making the product), which they are not—they range in size on a 13/15 denier from 11 to 17 deniers—then we would find that the finer size would be evened up by the coarser sizes, and the thrown thread would be more even than Lot B, where the coarse sizes predominate.

We find in practice that the sizes 11 to 17 denier even up in multiple threads, the degree of which is proportionate to the number of threads doubled together, and that the extreme sizes shown in the test are the ones that must be considered as influencing the unevenness of the product.

By penalizing the very fine and very coarse on Lots A and B with the multiplying factor 3, we have the following common defects:

	Lot A		Lot B	
Weak thread	10 × 3	30		
Very fine	20 × 3	60		
Fine	50 × 1	50	30 × 1	30
Coarse	50 × 1	50	100 × 1	100
Very fine	20 × 3	60	20 × 3	60
Total		250		190

This result shows a difference of 60 common defects, and, according to the classification grading, would class Lot B in the third grade and Lot A in the second grade. This demonstrates the need of reducing the unevenness to a common level in order to classify correctly the evenness of silk and get a ratio of clear product to the tests.

How can we determine whether the tests made on 30,000 yd. will represent the lot? Assuming that we follow the rules regarding sampling, we desire to say that every 10,000 yd. are scored on the "gage test," and if these results are compared with each other, and found uniform, it indicates that the tests will represent the lot, but if very irregular, one must correct the finding to conform with the test and use that rating in assigning the lot.

In our private practice we use the percentage method on the "defect test," counting 1 per cent as representing 20 common defects and deducting the finding from 100. We classify the

silk into a grade by letters as index values, calling A the most even silk reeled and H the most uneven.

INDEX NUMBER CALLED "PERCENTAGE"

The use of the term "percentage" has been quite generally accepted as an index number in the classification of raw silk.

The term "percentage" as used in the classification of raw silk is a number indicating a general level of quality and is applied to the basic qualities of raw silk found in a grade.

The "evenness by inspection test" uses the term "percentage." The 100 per cent panel represents practically perfect reeling, the other numbers indicate only a level of evenness consisting of a range in number and sizes as shown by panels.

I desire to call attention to the fact that in the assignment of raw sik by the "evenness by inspection test," one must remember that the number of evenness defects by this test is just about twice that which the "defect test" shows for the same grade, as will be shown by the following:

The standard panels of 500 yd. each show the following streaks of uneven threads:

100 per cent	No uneven threads
90 per cent	One
80 per cent	Two
70 per cent	Three
50 per cent	Four
30 per cent	Six
10 per cent	Seven

As the panels do not represent a grade but only a level of evenness, giving a definite number of defects and size, we shall proceed to determine the number of defects in a grade by following the procedure of finding the grade by the "evenness by inspection test."

(Actual counts of the evenness defects show that only two thirds of the theoretical number are scored, and we shall use two-thirds of the theoretical as a correcting factor in these studies.)

The Grades

A triple extra silk is given as one having a general average of 90 per cent and over, and a penalty average of 80 per cent and over. Special reeled silk we find will at times show an average of 98 per cent. Such a silk will represent about 105 defects on 300,000 yd. but by applying the correcting factor of two-thirds, we have 70 defects on 300,000 yd. A 90 per cent silk, with a penalty average of 80 per cent composed of the following panels:

100 per cent	20
90 per cent	5
80 per cent	10
70 per cent	5

would show 600 defects times two-thirds, or 400 defects on 300,000 yd.

A Grand XX, according to rules, ranges from 85 to 89 per cent, and an 85 per cent silk with a penalty average of 75 per cent composed of the following panels:

100 per cent	10
95 per cent	10
90 per cent	6
80 per cent	4
70 per cent	5
50 per cent	5

would show 885 defects times two-thirds, or 590 defects on 300,000 yd., about 40 defects to 1 per cent. The reader will please note that the "defect test" calls for 55 on 30,000 yd., or 550 on 300,000 yd., which shows that what is called a GR XX by the "evenness by inspection test" is called an Extra by the "defect test."

To get a GR XX by the "defect test," it is necessary to get a 95 per cent by the "evenness by inspection test." If, as has been said, where the uneven threads are graded into groups of 50, a direct relation is found between such a group and the number of uneven stockings, it will be apparent to the student

and the practical mill manager that when a GR XX shows 590 defects and a XXX shows 400 defects, the difference, 190, represents nearly 4 evenness groupings; and that, with such a range in number, the best of a GR XX and the worst will be so great that no repeatable results will be obtained. We therefore do not find that a direct relation exists between the grading of the "evenness by inspection" and the number of uneven stockings when manufactured under like conditions and colors.

As a GR XX ranges from 85 to 89 per cent, this makes possible a finer subdivision of the grade by percentage, and within the limits named, but the difficulty then presents itself of repeating the classification that is done by the method.

A further use of percentage, I find, exists among those who are not privileged to follow up the silk in mill operations and arrive at plus costs, and who must depend upon the reports and complaints from throwsters and manufacturers to determine the suitability of a silk to specific products. The best we can do in such cases is to substitute an index number, called "percentage," for the plus costs and govern the assignment and selection of raw silk on that basis.

Grouping Like Characteristics

We shall close this chapter on disposition by grouping the products where the prominent characteristics are alike or nearly alike in mill operations as they have appeared to the author:

First, weaving in the gum single thread and knitting in the gum single thread. We have already discussed the weaving in the gum single thread under "plus costs." For knitting in the gum single thread an average cohesion is required. Weak, very fine, and brittle threads are very objectionable, and cause fabricating losses. Unevenness is very noticeable.

Second, knitting hosiery in the gum multiple threads. Under 7 thread, very even silk is required on dark shades. The raw silk should be reeled only in soft water and that cleaned often enough to prevent the thread collecting the scum in the

reeling basins. Mixtures of hard and soft natures in 10-bale lots should be avoided.

Major cleanness defects should be low.

Third, weaving silk dyed in the skein, pure dye and weighted including organzine and trams. Skein dyeing opens the fibers, and minor defects and neatness must be low in number on products calling for quality. Tin weighting requires strong silks. Evenness and cleanness qualifications are dependent on the nature of the product.

Fourth, knitting silk dyed in the skein, pure dye and weighted, and warp knitting on boiled off tram. Hosiery knit ingrain requires a silk low in cleanness and neatness defects. It must be strong to stand weighting. Evenness is very essential. Brittle threads are very objectionable.

Fifth, hard twists, such as crêpe, radium, and grenadines. The finer threads such as georgette crêpe require an even thread. The thread should be pliable made so by soaking so as to be uniform in twist, avoid pin head kinks and snarls when weaving. The hard gummed silks are not suitable for hard twists unless properly soaked and made pliable.

Sixth, machine twists and sewing threads. As the finer sizes run over 20 threads of $^{13}/_{15}$ denier raw silk, they even up; and unevenness, therefore, is not essential. The weak and very fine threads are objectionable, as they increase the operating costs.

PART II

STUDIES OF MANUFACTURING EFFICIENCY

Much has been written upon the control and management of men in machine shops, foundries and other industries, but little can be found on the peculiar problems one meets in the management of boys and girls, and young men and women, particularly in the silk-throwing industry.

I do not presume to have attained a goal in scientific management that I can hold up as an ideal; rather I am only striving for it, but believe that I have reached a higher standard by having had an ideal to aim for. My motive in passing this experience and knowledge on to others is that it enlarges my own vision in everyday management problems and keeps me up to par, and also that I propose to show a better way than haphazard guess work.

I present herewith my observations on the condition affecting the supply of labor, human engineering problems, attitude of executives, principles of scientific management, qualifications of superintendents and overseers, the analysis and selecting of help, welfare organization, social activities, labor troubles, and actual problems in human engineering.

Process Not Simple

The impression appears to prevail among a certain type of manufacturers that throwing is a simple process, and that anyone can run a throwing plant. I have observed in my mill experience that there is a difference between simply running a plant and managing it efficiently—or, in other words, between producing a good thread without unnecessary waste at a profit and producing a thrown thread full of defects with a high percentage of unnecessary waste and no profit, followed by complaints and claims.

Promoters have persuaded communities that there are big profits in throwing, and a number of towns have erected and equipped mills; but too often the only return they received for their investment was part-time employment for idle hands in the community, and many unpleasant experiences and a loss of hard-earned cash.

Manufacturers have started their own throwing plants, but in some cases they have installed unsuitable machinery, and in others have had the machinery supervised by unskilled and incompetent superintendents. Some have chosen the wrong location, or made the throwing plant a part of another manufacturing plant, only to find that, while the operations are simple, it requires skill to do the work quickly, well, and cheaply with a reasonable allowance for waste. To operate a throwing plant efficiently on diversified threads requires first of all an efficient management equal to that of any other textile department, and it takes more time and effort to build up and maintain such an organization than is generally appreciated.

Supply of Labor

Every business has labor problems to combat that are peculiar to its own line of work. On account of the keen competition, irregular business, and many lean years, the average profit is low, and the cheapest labor in the community is employed—as young as the factory laws governing minors permit. Throwsters get their help from homes where they have never done a full day's work, and have been spoiled by an indulgent mother, indifferent father, or both; from homes where curses and force are the only methods used to gain obedience; and from all nationalities and creeds.

Twenty years ago, throwsters were employed, some as young as twelve years, who came mostly from the homes where the father spent his earnings for rum. They were poorly clad and undernourished. They had no clothes suitable to wear to school, no money to buy food, and generally the mother prevailed upon us to give them something to do so they could at least earn their food and clothing. When we did employ them, we gave them light work, such as lacing, cleaning bobbins, marking tags,

and running errands. There were others who were orphans, and these had either to be given light and useful work or be subjects of cold and spasmodic charity.

My sympathy was always with children under fourteen years of age. They were a constant care; and I welcomed the day when the factory laws prohibited the employment of children under that tender age. We met cases, however, where the law imposed a considerable hardship on the parents and children, and where one would have liked to help.

I remember a case in which the father was killed on the railroad. The family received no compensation, and the mother was left with two girls, one nearly thirteen and the other not quite fourteen, without means of support. Since the girls were large and strong for their age, the mother was tempted to pass them both as a year older, so as to get work. Instead, however, she decided to be honest, state her case frankly, and see what could be done. She said they had to live, refused to beg, were willing to work, and only asked for a chance. When the age limit was raised to fourteen years for the employment of minors, a widow's pension was granted by the state wherein the incident happened, but on her application to the board she was refused this pension because the funds were exhausted. A letter to the district attorney, stating the case and asking permission to help the family by giving them work, resulted in securing a pension.

The prohibition amendment had a decided effect on the supply of labor six months after it went into effect. First, we found that the children in the homes of the laboring class continued in school longer. Second, when they did apply for work they were better clothed, better fed, and more dependable.

Other conditions that have reduced the supply of labor within the last seven years are higher wages to the mechanic and laborer, educational requirements, and factory laws.

Lower Wages than Weavers

When a large throwing and weaving department occupies the same building or group of buildings as a part of the same organization, the wages in throwing are generally kept below

those of the manufacturing department in order to encourage the best help to learn warping and weaving. This frequently causes a shortage of first-class help in throwing and increases the trouble for the throwster. The throwster who has combination machinery operation on an efficient basis as to costs, speed, and production per operator, and who produces a first-class thrown thread, requires skill equal to that required in warping and weaving; and, when the disparity in wages is too great, it frequently leads to labor unions in the throwing department and strikes affecting both departments.

It is unwise to operate a large throwing and manufacturing department of the same organization in one group of mills, or in the same vicinity, unless wages are nearly alike and consistent with actual work performed.

The school laws of New York City require now that minors under seventeen years of age who have not acquired a high-school education attend a continuation school one-half day a week, where they are taught millinery, cooking, dressmaking, etc., and, to foreigners, common school studies. Inquiry among the pupils of the continuation schools shows that about 10 per cent like it, 50 per cent go simply because they must, and the rest try to *avoid* it by giving the wrong age when applying for employment and by playing truant.

As one cannot send his help to school and keep the machinery in operation, he is limited in the number of this class that can be employed. To break away from the training of the mind, take up routine work, and acquire skill in finger movement and endurance is not to the liking of our modern girls. Sometimes I wonder where the future factory workers are coming from, if the state authorities continue to raise the educational requirements and the boys and girls reach an era when they no longer want to work at anything except "white collar" jobs.

Desire for Work

Once in every boy's and girl's life there is a period when he or she wants a job and wants to do his or her bit of life's work. At that period of life they find happiness in the sense of achieve-

ment or of having a part in doing the real things of life. The wage and thrift of parents, the number of children in the family, and the amount of spending money they receive weekly, largely governs the age when a boy or girl wants to go to work. The parents owe to their children an education, and the state insists upon this; but at what age a boy or girl shall be given his or her choice as to continuing at school or going to work is a problem that can only be solved individually. I touch upon it only to show it as one of the conditions that govern the supply of labor for a throwing plant.

The supply of young men and women in the future for throwing is not encouraging in the face of increasing state restrictions and educational requirements, which keep some of them out of the factory until they become too proud to work. Encouraged by the well wishes of indulgent and misguided parents who cannot agree to manual labor for their children, many of them become corner flirts and poolroom loafers, who largely make up the criminal class.

Undesirable Citizens?

Does a boy or a girl who goes to work at an early age and thus becomes economically independent of the parents tend to become an undesirable citizen? My experience has been that a very low percentage of factory workers are found in the criminal class; rather, as our modern factories insist on obedience and proper deportment and train the factory workers as producers, many of them become leading citizens and advance to the front ranks of industrial life.

Among the working class, there are still a number of parents who receive their children's wages, supply them with food and clothing, and give them weekly allowances. Occasionally I have been asked to intercede for boys and girls for a greater allowance, and then I have suggested that the allowance be made in proportion to their earnings so as to give the help the incentive to do their best. Will the increase in educational requirements gradually bring about a class of young people who will avoid work in textile industries, and will we be forced to have our throwing done in Japan and China?

Last 25 Years

Let us analyze the conditions as they appear to us in the light of development during the last 25 years.

First, statisticians show that the birth rate among the intellectuals is failing alarmingly, and that the present generation will soon die out. Therefore, we need not fear a predominating influence from that class.

Second, Abraham Lincoln said that God must like the common people, as he made so many of them. That still appears to be the situation in this generation. Someone said that there are only three generations between shirt sleeves and shirt sleeves—in other words, the first generation earns the money, the second spends it, and the third goes back to work again—and that, if the wealth of the country were equally divided between man, woman and child, in five years' time it would be back again in the class of people who now have the bulk of it.

Third, educators of vision and keen comprehension of what an education should do for the rank and file of the young people of this great industrial country are offering them vocational training during the last few years of school life. This is breaking down the stigma against factory workers so prevalent in the smaller cities and towns 20 years ago. This is increasing the supply of young people for factory workers.

Fourth, the increasing desire for amusement, sports, dress, and luxuries is also increasing the supply of labor.

Supply Increasing

We receive into our mills today a more intelligent class of young people than we did 20 to 25 years ago, but to hold them long enough to become skilled workers at routine work is the big problem. In the schools they are treated as equals, taught good manners, and instructed in the care of their health.

The state laws direct what a minor may or may not do, and specifies the number of hours he or she may work. Popular magazines and labor organizations stress the demands for better working conditions and a fair deal.

I do not find the supply decreasing, but rather increasing. However, it is not keeping pace with the increasing demand for female workers in the large industrial centers where the schools are on part-time session in order to accommodate all the scholars. Office help are on the waiting list.

I am convinced that if the throwsters in general are to get their share of labor, the general attitude toward help that work at throwing must be changed. This change must start with the owner and follow right down the line, including manager, superintendent, assistant and forepeople. We must dispel the idea that anything is good enough for help that work at throwing. We must treat them as they deserve and pay them a wage which will be nearer to the wage of other textile workers in the community.

Human Engineering

Throwing requires work in human engineering, either by specialists or superintendents. Regardless of who does it, it will devolve upon the management to adopt an advance program and bring the organization into line according to the civic standards and general intelligence of the help where the mills are located. We have watched, studied, and examined machinery with an intensity that has narrowed our vision and disturbed our outlook. We have studied the production of each frame with apparently the one object of getting the maximum production of each frame. As a result, we have our machinery in every up-to-date mill in excellent order.

While this has been going on, we have not given the proper attention to those who operate the machinery. At least, we have not studied or examined our help with the minute attention that the machinery has been given. Our problem today is not only to maintain our machinery in perfect condition, but to adapt the more intelligent labor at a higher wage to higher speeds and better equipment without overfatiguing them.

Attitude of Executives

The first requisite I find is a scientific attitude on the part of the mill owners, managers, or superintendents. When an

individual or company starts an industry in a town or city with the express purpose of getting all that is possible out of the help and giving just as little as possible, the community soon senses that spirit and eventually retaliates by encouraging the help to organize and force higher wages by strikes or walkouts, or by inviting and offering inducement to other industries to locate in the community. This creates a demand for labor, promotes a higher wage rate, a greedy spirit, suspicion, discontent, a heavy turnover in labor, and a low morale; and often shows itself in poor product and low earnings.

On the other hand, when the management shows a spirit of service to the community, aims to give work to idle hands so they may obtain more of the comforts, luxuries, and pleasures of life, pays the best wages the business can afford allowing for a proper profit on the investment, and takes part financially and otherwise in the social activities of the community, it creates a feeling of common interest, good will, and a splendid morale. Then there naturally follows a better product. If the management is otherwise efficient and progressive, it not only produces a profitable organization but also a happy and contented industrial community.

Fair Wages

The practice in nearly all industries in the past has been to let the labor stand all the loss of time off during slack periods, sickness, waiting for raw material, changes of machinery due to changes in style, equalizing of departments, and vacations. As the public has not been willing to absorb a necessary increase in price on all commodities so as to enable the management to cover the increase in cost to give the labor steady work and wages during sickness, it is not altogether the fault of the mill owner that these conditions exist. However, an awakened conscience and higher wages to our American workmen have made it possible in some lines of merchandise to pass on to the buyers a higher price; and a number of industries are aiming through welfare organizations, profit sharing, and group insurance to make up for unavoidable suffering and privations so far generally passed on to labor.

Our modern methods of efficiency and accounting often bring about acute labor conditions. This is particularly so in the case of absent management, where cost sheets only are studied and also where the piece-work rates are based on a high working rate with silk running well, permitting either no allowance for silk running poorly or only a nominal one—and then only when demanded by the help.

The more intelligent workers cannot be bullied, and they expect to be paid for their skill and actual work performed, regardless of the amount produced. They consider it a great injustice that one girl having a few breaks and an easy time should earn a high wage, while another, frequently working twice as hard on poor silk, earns a low wage or receives only a meager allowance after making a fight for it. It requires no argument to convince any manager of the unfairness of such conditions, but how many managers ever investigate to what extent such practices are followed in their organization and determine how much labor unrest and demands for higher pay arise from such practices?

Change in Attitude

The change that I believe is necessary in the attitude of mill owners, if the throwing industry is to get its share of a more intelligent class of help in the future, is that they must recognize the importance of giving the help a wage and other mill conditions equal to that supplied by other industries in the community for similar services and skill. There is an attitude that, simply because labor accepts less wages in throwing, such labor is of a lower social class, anyone is good enough to oversee them, and anything is good enough for them in the way of heat, light, and other comforts in a mill. This attitude must be changed.

I realize that, to bring about a general change, greater earnings are essential. Past experiences show that the throwsters have not had their proper share of the profits in the silk industry, which suggests the need of cooperation to secure that end along proper ethical and legal lines. Gentlemen's agree-

ments on prices appear to last only so long as there is enough throwing to go around and keep all fully supplied.

History shows that when an organization or industry unites to raise itself to a higher plane in relation to its workers and does not aim solely for its own profit, the buying public responds to the demand for higher prices and is willing to absorb higher costs, while both the manufacturer and employe profit.

Smaller Factory Units

The second requisite that I recognize as necessary to secure and hold a more intelligent class of labor at a reasonable wage rate is smaller factory units under a general supervision near the homes of the help, so that they can go to and from work in ordinary clothes, save carfare and cost of lunch, and avoid holiday attire. This would reduce labor turnover and create a more happy and contented worker. It would also give the help more time for home and social activities, and help them to overcome the monotony of mill life.

In our large cities, the congestion in trolleys, subways and buses is becoming acute. To spend one-half to two hours going back and forth from home to work daily, hanging on a strap, saps too much energy from our help, especially those who must stand all day or have only short rest periods.

Another benefit in smaller units is that they permit one to specialize on one particular class of thread, standardize its operations, lower the costs, and make a better product. As a minimum wage tends to centralize factories in large industrial communities, compels help to leave home and to board out at higher rates, and obliges them to dress better, they are not as well off as at a lower wage rate in their home towns. I do not find that a minimum wage is helpful to an industry and labor.

Scientific Not Systematic

The third requisite that appears necessary is to train superintendents to analyze carefully each problem, demand facts, avoid guessing, deduct the logical conclusions, establish standards, make plans, direct, and control. William B. Cornell, professor

of management at New York University, calls this scientific management. He says:

> Scientific management lessens the cost of production without injury to the health of the workers, improves factory conditions, increases the earnings at a lower cost, and gives better service to the trade. It differs from systematic management in that system is merely an aid to scientific management, and not the all-important thing as in systematic management.
>
> Scientific management plans methods of performing routine work along accustomed channels which can be handled by less experienced help, leaving those in authority to devote their efforts to master work; and, while system is used extensively under scientific management, it is not the paramount feature.

In the throwing industry, a superintendent is generally the one in charge of a throwing plant, directing and controlling the business and technical details that are necessary to plant operation. He acts as the representative to the trade when doing a commission business, and to the main office when the plant is only a unit of a chain of mills in the commission business or is part of a manufacturing concern doing its own throwing. He also directs all practical mill operations, and is responsible for the production, quality of work, costs, and general care of plant. He is the company's representative in the community. Sometimes the technical and administrative duties are performed by a manager, by officials, or by owners.

W. B. Cornell says that there is no set rule that can be given to insure success as an executive.

> There are certain traits and methods of conduct which are essential to executive success. A few fundamental characteristics must be inborn, but others must be developed. A regard for the rights of others, a good personality, and a trained mind are essential. The executive must be a believer in others, not a fault finder. He must look beyond the criticisms and complaints, and see the essentials.
>
> The quality of leadership must be inherent, but it cannot be allowed to lie dormant nor run rampant. Self-control is requisite to success as an executive. A mild but firm executive is reliable. He can be depended upon to force all issues openly and fairly. Last, but not

least, he must have a trained mind, must be a seeker of facts and one who analyzes his problems, rather than one who jumps at conclusions.

This very ably states the essential qualifications of a throwing superintendent, and we will take it as a basis of a further consideration of qualifications.

Promoting Foremen

In my experience as a general superintendent of throwing, I have been called upon to select men to manage various plants. Whenever it was possible I have advanced promising men from the ranks of foremen to fill these positions. These men know the policies of the company and one knows their plus and minus qualifications. I have found men who were successful as department heads, but failures when put on their own resources as superintendents of a small plant. I have found others who were successful in a small plant until it grew to a size where they had to depend on others to do the work, and then they failed.

In the first instance they failed because they lacked initiative, did not have trained minds, could not state clearly in a letter any unusual occurrence, thus keeping the main office in a quandary, and requiring unnecessary visits by the general superintendent. In the second instance they failed simply because they were only good workers and lacked the necessary qualifications of leadership.

In advancing a foreman from your own organization to superintendent, it usually follows that unless he is willing to pursue a definite plan to strengthen and build up his weak points, or unless he has an ambitious personality, he may just drift and eventually must be replaced by a better man. If one of these features is lacking, it is better to secure a trained man elsewhere. In the selection of an outside man, of whom nothing is known except what he himself is willing to tell or what his recommendation may say, unless one has a definite plan of analyzing such a man, too much consideration is often given to a pleasing personality and too little to the other more essential qualifications.

Measuring Ability

In order to follow a general plan of building men, I have worked out for myself a method by a study of the principles used by competent engineers, such as Harrington Emerson on personal efficiency; Dr. Blackford on science of character analysis; Taylor and Gilbreth on time and motion studies; W. B. Cornell on organization and management principles; and many others in trade and managerial journals. As I have had the pleasure of seeing a number of men developed into first-class superintendents under it, then holding responsible positions and making good, I pass it on as having been tried and proved sound in principle. I hope it may prove helpful to others. It has been found useful in interviewing applicants for executive positions, as the conversation can easily be directed in a way to cover the essential qualifications, and thus measure the ability of the applicant correctly.

The essential qualifications are as follows:

Education
Practical experience
Physical recreation
Mental recreation
Personality

Good or Plus Qualities

Initiative	Tact
Planning	Sympathy
Despatching	Loyalty
Character	Patience
Punctuality	Common sense

Bad or Minus Qualities

High strung	Variable
Moody	Sensitive
Bad temper	Egotistical
Intemperate	Lazy
Jealous	Gossipy
Treacherous	Pessimistic
Nervous	Not ambitious
Impatient	Forgetful
Grouchy	Excitable

Education

Replies to a questionnaire sent out to mill managers show that the majority of managers preferred to select their prospective executives from men who had had a high-school education, and one or two years in a textile or trade school. They preferred such men to graduates from universities and colleges, as the impression appears to prevail that such graduates are not willing to get down to the work necessary to acquire a knowledge of the details of mill operations, or familiarize themselves with the problem of the working class, and therefore could not and did not sympathize with them. Because of this they antagonized the workers and rarely became successful superintendents.

I will venture a guess that the majority of throwing superintendents have not had beyond a high-school education, but there are many able and successful men among them. We will possibly find that they have acquired the equivalent of years of advanced education such as a school or college could not give them, through years of home reading and study, and a thorough application of what they did know through inborn and inherent qualifications.

Practical Experience

As to his practical experience, it appears desirable to know in how many departments he has worked and how long he has served in each of them, as follows:

Mill operation	Belt fixer
Assistant foreman	Foreman
Assistant superintendent	Superintendent

Business and Technical Training

Clerical	Shipping
Bookkeeper, cashier	Analysis and testing

Physical Recreation

I should desire to be informed on what physical recreation he takes, such as bowling, baseball, fishing, hunting, boating, skating, autoing, working in garden, etc., and his activities in lodges and clubs. This may appear rather critical, but it has

an important bearing on what confidence the community will have in him and the company, in case of labor disputes or in case the company needs financial help and desires to make a loan at the local bank, even though he personally may not participate in the negotiations.

Mental Recreation

Taking up in detail the major qualifications, it is necessary to know what education the applicant has acquired, what course of studies he has since pursued, and what magazines, secular, religious, trade paper or scientific, he now reads. This is to ascertain whether he has stopped growing mentally or is still developing his mind, and thus determine what may be expected from him in the future. As a superintendent is generally looked to by the community as the representative of the owners or company, it is desirable to know what kind of impression he will make by his private life, and this will largely depend on whether he spends his time in the gambling dens, pool rooms, cigar stores, and corner groceries, or takes part in the civic and religious life of the community.

Personality

Personality is a charm of manner which Mr. Emerson says—springs in its best form from four sources. First, justice; second, desire to serve; third, kindliness; fourth, self-discipline.

Justice involves a keen recognition of others and seeks to give a fair deal. We may be perfectly just in our treatment of others in a cold, dispassionate, exciting manner, which repels, chills, and antagonizes rather than one which draws, warms, and awakens friendliness.

A true desire to serve is coming to be recognized in the business world as the very heart of business building. Similarly, in human relationship it is true desire to serve that gives genuine charm and leads on to the higher success.

Kindliness smooths the rugged and stern rocks of justice; which, when administered harshly and coldly antagonizes but

when warmed by kindness makes friends with those who must be punished.

To require a pleasing personality one must cultivate responsiveness for the feeling of others, a lively interest in other people and things, force, calmness, self-control, beauty in tone of voice, friendly expression of face and good expression of thoughts. Study to say things that help to uplift, encourage, and inspire.

Duties in Large Plants

A superintendent in a large plant should not perform any routine work such as can be done by cheaper labor, but should devote his time to planning, directing, time studies, and experimental work leading to the improvement in quality of the product. He should study and build up his labor by individual efforts through his assistance and teaching. To do this effectively, a practical knowledge of mill operation is essential, as he will then be able thoroughly to analyze any problem that may arise, solve it in a logical manner, and save unnecessary experiments.

Duties in Smaller Plants

In the smaller plants, with but one class of thread, the time may hang heavy on a superintendent's hands, and as he rarely has the facilities or equipment to carry on plant research work, it is better to have him devote part of his time to the clerical or practical operations, or both, as the size of the plant and other conditions may warrant. An executive having much spare time is tempted to devote too much of it away from the plant or to become lazy, which leads to neglect, intemperance, pessimism, jealousy, and to gossip with forepeople and help.

It is always the busy man that does things. One of the difficulties met by an executive in small plants is that the production does not permit the paying of the salary necessary to hold a good man, and frequently one finds a good man who is not willing to perform any part of the minor executive position because of a false notion that it is beneath the dignity of his position. If he were the owner of the plant he would plan for himself a reasonable part of the non-producing duties. This

frequently can be accomplished by offering the superintendent a commission besides his salary, depending on the saving in overhead. But one must guard against the plant being undermanaged, and avoid overworking the superintendent during the building-up periods thus causing him to acquire many of the minus qualities, such as nervousness, impatience, grouchiness, and excitability.

He should know how to judge the qualities of raw silk in a practical manner so as to be able to make an intelligent report that is comparatively true to working conditions, and indicate what may be expected by the manufacturer from the finished thread.

A busy or industrious and energetic superintendent unconsciously becomes a leader and not a driver and he inspires others by example to do their best, which is the better way.

Initiative, Emerson says that:

> . . . "initiative is resourcefulness in observing, learning, and putting such knowledge into practice; it is born of two mental qualities:
>
> First, constructive thinking; the power to produce a new idea.
>
> Second, the courage, energy, and aggressiveness to put the new idea into action.
>
> Imagination is the base of initiative and is the faculty of the human mind which has created all of the progress achieved by the human race from the beginning up to the present time.
>
> Self-education for initiative consists, first, in the nourishment of the mind with accurate complete knowledge of the things with which we have to deal, a careful comparison and correlation of that knowledge by meditation, and seeking new and useful combinations of things already known; second, in the development and direction of courage, energy, and aggressiveness.

VALUE OF FORESIGHT

Planning.—Planning means looking ahead, deciding what is to be done, how much time is to be allotted to the work, and what materials are necessary for its accomplishment. The difference between the man who plans and the one who does not plan is the difference between the man who is forever getting into emergencies and trusting to luck to help him out, and the

man who carefully and systematically so orders his life's work that he never finds himself face to face with an emergency. Some men do not know what they need until the need is upon them; others by the simple power of imagination are always prepared. Fifteen minutes of planning and head work will save hours of foot work.

Despatching.—Despatching is working your plan. It is not enough to plan things, but one must work that plan. It implies beginning on time and finishing on time; ordering your supplies on time and having them on hand when needed; getting the machine repaired before it breaks down and work ceases. Despatching does not procrastinate.

Despatching does not mean carrying a message from the manager to the help and letting it go at that; but it also necessitates the following up of that message to see that it is carried out. Despatching does not mean tacking up a notice and expecting that notice to bring about the desired results; but rather it means to use that notice simply for what it is intended, namely, to keep before the workers what is desired and then carefully following up to see that the rules are observed.

The other qualifications: character, punctuality, sympathy, loyalty, patience, and common sense, are also given as qualifications for minor executives such as foreman and teacher, and will be considered in detail under qualifications for foremen.

Get Results in a Kind Way

The fourth requisite that appears necessary to scientific management is to train foremen to get results in a kinder way by not only giving but demanding a fair deal.

Years ago the best foreman was considered to be one who had the inherent qualifications to drive help to get results. I recall a director once advising me to swear a little once in a while, saying that it awed the help and produced results. My experience is that with young people cuss words are harmful and should never be used.

I recall a throwster who put up a plant in a certain town, which for ten years was the only industry there employing

young people. They doubled their capacity and still had plenty of help. But then another throwster entered the town and the trained help left the first plant by the score. They walked ten blocks farther for the same pay, simply because they said they would not stand the bad language and the bullying any longer. Learners ceased to apply, and in a few years the owners were compelled to move part of their plant to another town.

What are the essential qualifications of forepeople and assistants, what are their duties, and how are they to be trained?

The duties of forepeople in a throwing plant, of course, differ under various methods of management, but the following will serve as a fair outline of what is expected:

(*a*) Discipline and keeping up morale.
(*b*) Training new help.
(*c*) Assigning help.
(*d*) Laying out work and ordering raw material.
(*e*) Keeping time and piece-work record, and overseeing same.
(*f*) Making reports and inspections.
(*g*) Preventing excessive waste.
(*h*) Receiving raw silk and sending out finished work.
(*i*) Preventing mixture of lots and thread.
(*j*) Fixing bobbins and cut skeins and rings and overseeing same.
(*k*) Gathering waste and rings.

QUALIFICATIONS OF FOREPEOPLE

The qualifications of forepeople are as follows:

(*a*) Practical experience as an operator and teacher.
(*b*) Character.
(*c*) Punctuality.
(*d*) Tact.
(*e*) Sympathy.
(*f*) Loyalty.
(*g*) Patience.
(*h*) Common sense.

(a) Practical Experience

Overseers cannot properly direct others in practical mill operations unless they have done the work themselves. Skilled workers cannot respect or be expected to follow a forelady who is constantly or even occasionally misdirecting them. I have met conditions where no skilled workers would accept the responsibility because of acute labor conditions where women of executive training were necessary to secure discipline. In such cases one must depend upon skilled workers to teach the department operations until the forelady has acquired sufficient skill to direct that part of her duties.

(b) Character

Reputation is what people think we are, character is what we really are.

I do not like thee Dr. Fell
The reason why I cannot tell,
But this I know and know full well,
I do not like thee, Dr. Fell.

This rhyme expresses a common human tendency. We are attracted by some people and repelled by others. The man or woman who cannot control his or her passion, who constantly indulges in excesses, soon loses the respect of his or her subordinates. One must be master of himself if he will lead others. Character unconsciously commands respect, and this is essential in the control of young men and women.

A woman not a member of a church, whether Catholic, Protestant, or Jewish, is rarely a woman of character, and it is safe practice to avoid hiring such a person as forelady.

I have never applied this rule in selecting a foreman, as both men and women, whether we reluctantly admit it or not, are more tolerant of the little sins of a man than of a woman. When one employs a man, the judgment of his character depends on whether he gambles, habitually gets drunk, goes out with his female help on petting parties or joy rides, and whether he is honest. Unless a man is of high character he should not oversee young women.

Dr. Blackford says:

> By character we also mean reliability, and general trustworthiness; a man may seem to be wonderfully efficient in many ways, but work, like everything else a man does, is an expression of character, and a man cannot be dishonest in character and express honesty in his work.

If I were a manufacturer giving out throwing on commission, or operating my own throwing plant, I would carefully inquire into the character of the superintendent in charge.

(*c*) Punctuality

A punctual foreman or forewoman indicates a well-trained and self-disciplined person of orderly habits. Such persons are on time because they do not allow things to drift, do not procrastinate, and do not allow the work to proceed in a disorderly manner.

To attain a well-regulated and successful department, there must be clear and definite rules to be observed, in order that a group of workers may work together harmoniously. Conformity to these rules must be secured by training, by teaching, and by penalties; and this must be gone about in a well-ordered manner, typical of a well-disciplined person. It must be remembered that consistency of discipline is more important than strictness or severity. Dr. Blackford says, "Nature has a way of eliminating those who are lazy, dilatory, disorderly, uncleanly, intemperate in eating, drinking, working and playing." In a department the foreman imposes natural penalties for infractions of these rules, and by proper discipline causes the department to function efficiently.

As punctuality indicates one of the essential qualities of good management—*viz.*, discipline—I have placed it second on the list of qualifications for a foreman.

(*d*) Tact

Tact is that desirable qualification and ability to secure cooperation from help by appealing to their positive moods, such as loyalty, duty, and justice; and overcoming the negative

moods, such as hatred, resentment, suspicion, and anger. One need not be a psychic to sense a spirit of harmony, team work, enthusiasm, and happiness, nor is it difficult to feel an atmosphere of gloom, suspicion, resentment, petty jealousy, state of mutiny, and careless indifference. There is a reason for every action of mankind. Tact seeks the motive prompting such actions and deals with the motive rather than with the individual.

(e) Sympathy

Sympathy is that feeling for others that prevents one being cruel, and displays the spirit of the gentleman and gentlewoman. It is kind; but, as true kindness must also be just, it does not tolerate and cover a multitude of rule violations. Sympathy creates sentiment, to which we owe all of the fine things of life. It puts itself in the place of labor and pleads for justice and a fair deal. It harbors no ill will and tolerates no oppression.

(f) Loyalty

John D. Rockefeller says, "Loyalty is singleness of purpose." Fra. Elbertus says,

> Loyalty is better than cleverness. If you work for a man, in heaven's name work for him. If he pays wages that supply you your bread and butter, work for him, speak well of him, think well of him, stand by him, and stand by the institution he represents. I think if I worked for a man, I would not work for him part of the time, but all of the time. I would give an undivided service or none. If put to the pinch, an ounce of loyalty is worth a pound of cleverness. If you must vilify, condemn and eternally disparage, why resign your position, and when you are outside, damn to your heart's content. But, I pray you, so long as you are a part of an institution, do not condemn it. Not that you will injure the institution—not that—but when you disparage the concern of which you are a part, you disparage yourself. And don't forget, "I forgot" won't do in business.

An employe who changes his or her job frequently, and who has much fault to find with every job he or she holds, is usually not strong on loyalty. One who permits a state of unrest to

grow in the department and does not report to higher authority is not loyal to the management.

(*g*) Patience

It is no credit to a forewoman to be patient with wrongdoers, nor is it good management to fire an offender for slight infractions of the rules. Patience seeks to correct these faults and show a better way. Patience often disciplines to correct and to secure better service.

When weeks and sometimes months have been spent to teach a new hand, and he has acquired considerable skill, it is very foolish and inefficient to discharge such a one for offenses, when it requires much less time and patience to correct these offenses than to bring in another learner and go through the same routine again, possibly to find the same fault when the learner arrives at that stage of the work.

Willing workers always produce and give better service than forced labor. Patience seeks to stimulate the driving force within the worker, so that he faces the work with a self-inspired eagerness.

(*h*) Common Sense

Harrington Emerson says:

> Common sense is sound practical judgment and not hasty, mistaken, prejudices or illogical judgment. It is the result of knowing the facts, knowing them accurately, and giving each its proper consideration; and reasoning from them logically.
>
> The second element of common sense is right feeling, which builds up the mind and body; wrong feeling tends to destroy the body.
>
> The third element of common sense is intuition. Sometimes we get a hunch or a strong impression that something will happen if we do thus and so, but not all of these hunches are reliable. They must be checked up with the facts and acted upon when they prove true. Beware, however, of mistaking a mere lazy guess for intuition, and using it as a substitute for the hard mental work of judgment.

A crowd of men sat around the village store discussing a fire the night before. Said one young man, "What a dumb

animal the horse is. Three times I had that valuable horse at the stable door, and every time he broke away when he saw the fire, and darted back into the stall and eventually perished in the flames."

In the crowd was an old man of a philosophical mind whom the village folks called Uncle John. He was a lover of horses and took exception to the statement of the young man.

He said: "Young man, if you had shown as much common sense as that horse showed horse sense, you would have saved that valuable animal. Does not the horse go to his stall for warmth in winter, to cool off in summer, to be curried, combed, and to get his food and drink? Is it not a fact that all the comforts a horse knows about are found in his stall, and in time of danger is it not logical to expect that that is where he would go for safety? If you had put a blanket over his head so he could not have seen the fire, then you could have led him to safety."

If we fail to use common sense in applying the other qualities, we will often find ourselves irrational or weak and will fail as successful executives.

TRAINING OF FOREPEOPLE

We must recognize that a forewoman or foreman is the key woman or man in a manufacturing organization, and represents the help to the management, and the management to the help. One must have absolute faith in the integrity of these people, but they must show absolute lack of favoritism and be frank and open in consideration of all complaints.

Forewomen are generally selected from the most skilled workers, and have usually served time as teachers or assistants. Because of merit they have been promoted. They acquire a general knowledge of the policies of the management and how to train help, by observation and actual contact with the workers. Having been a department worker, they usually have a keen sense of sympathy, and one must be alert lest they be indulgent and tolerate a multitude of misdeeds.

I have found it the best practice to train one's own forepeople rather than acquire them from other organizations.

While this method meets some opposition from jealous employes, it soon disappears if the forewoman treats all alike, gives and demands a fair deal, and is properly supported by the higher executives. Full-time pay for holidays and vacations and an advance in wages are usually the inducements offered for the increased care and responsibility going with the job.

Having considered the qualifications of a superintendent and foreman necessary to manage a throwing plant scientifically, let us now consider the mill problems as they arise in a plant of good size from the viewpoint of the human engineer. As the throwing industry has, as yet, not reached a size to warrant the employment of an engineer trained along this line of work, we will consider it the duty of the superintendent to function, as the human engineer.

The Selection of Help

The work of analyzing and selecting the help is of primary importance. Experience shows that even though the work is simple and light, not all boys and girls make skilled winders, doublers, or spinners, principally because some of them never will be careful and others never will acquire the necessary speed.

1. Learners between the ages of fifteen and eighteen years are the most teachable; their fingers are more nimble, they acquire speed more quickly, and they stick longer than young people at any other age of life. At this age, too, they are usually living at home with their parents, who give them board free during the apprenticeship and low-wage periods.

Young men and women over nineteen years of age, unless they are light in weight and unfitted for heavy work, rarely make skilled throwsters; because at that age they are not willing to serve the four to six months necessary to acquire skill and speed, so as to run a full part and earn the maximum wage.

2. Learners must be strong enough to stand all day, and must have enough will power to endure a tired feeling until their muscles become developed to the task, and speed is attained by the sense of touch, when fatigue is no longer experienced.

3. The girls should wear low-heeled and comfortable shoes. Those who are too proud to do this soon drop out.

4. They must be nimble or quick so as to find the end quickly, tie the knot, and cut it off short and clean. Stout employees are usually slow and never make skilled workers. I have generally found it a waste of time to teach them.

5. Doublers and spinners must have good eyesight so as to count the threads and make an evenly thrown thread.

They must be conscientious and perform their task well without constant watching.

The ideals that the employer should aim for are: that each worker should do the work for which he is best fitted, that each should work in an environment in which he can do his best, that each should see and enjoy the results of his work, that each should be paid according to his efficiency, and that the ideal be within his reach without overwork.

Satisfying the Worker

Our second problem in human engineering is to find a way to keep our routine workers contented and happy, so as to reduce the labor turnover and thus avoid the excessive expense of teaching, the resultant bad work, and the excessive waste incident to instructing many learners.

We employ in a throwing plant of fair size various types of help. First, we find the ambitious ones who desire to rise to the top, who take every opportunity to learn the minute details of the task, and who find happiness and contentment in acquiring skill and knowledge in every department.

The writer will illustrate this class by giving his own experience, with the reader's kind indulgence:

I entered mill life at the age of fifteen years, worked two weeks for nothing, and then received $1.50 per week. The first pay brought to me one of the happiest moments of my life. I counted myself one of the lucky boys of the town of Bethlehem, Pa., as I had been selected from a large waiting list for an apprenticeship in spinning.

In two months' time I considered I knew enough of spinning and was ready for another job. Fortunately the boss also thought so, and I was promoted to bundling and shipping. At

that job I worked hard, and when we got ahead of reels I was sent out into the various departments, and this gave me an opportunity to get a well-rounded training which brought happiness to my work. After three years I found that the work included too much routine, and left to acquire a business training—later, however, to return to the same mill as office chief and eventually superintendent and manager of other plants.

Prefer One Job

Second, we find a class of employes who are just the opposite of the first class, who prefer to learn one job and stick to that, rather than be changed about from one department to another. We find in this class those who take a job only as a temporary means of earning "pin money" for sports, shows, etc.; others who wish to earn money to buy clothes better than their parents can afford to supply; and still others who take work only while waiting for a better job elsewhere, or until they arrive at an age when they can learn a trade, or marry and go to housekeeping. There is found also in this class those who have no ambition and are content with a square meal and enough clothes to keep them comfortable. In the latter class are those whose attitude may be similar to that of the man who was digging a ditch on a hot summer day without a hat on his head. A visitor asked him whether he did not fear he would fry his brains out in the hot sun. He answered with the question as to whether he thought that a man with brains would work in such a ditch.

In seeking for a reason for the apparent contentment of the second class, I find that their happiness is attained in performing their task with the least effort, and, therefore, with the greater comfort. In the course of time the work becomes so automatic that much of the fatigue experience when learning, and even when but half-skilled, is not experienced, and their happiness is increased because they are less tired than when changed about and wearied by constant eye strain and mental alertness.

Many want to be fresh for the dance, show, party or other social engagements, and they seek the easiest and quickest way to earn money which brings to them the desirable things of life.

Workers with Dependents

In the third class we find those who have dependents, or must help to support other members of the family, and by force of necessity must earn all they can. In this class we find many distressing and worthy cases, often a higher type of young people who are sacrificing a trade or a higher education to help provide a living for themselves and others. Their ambitions are high, and to them the routine work often becomes a drudge, and only a strong will and a high character prevents them from breaking down or running away from it.

From this class many of the forepeople and superintendents are recruited, chiefly because they stick long enough to become thoroughly familiar with the work, and show ability to direct others, having learned to master their own will. We also find in this class those who lose all ambition and never become efficient workers, because whether they earn more or less, they only get a living out of it, and they take the easiest way to it.

Ambition Throttled

The fourth class are the young people whose families have a common treasury into which all they earn must be put and from which but a pittance is given to them for their own use. Their ambition to excel is throttled, because, whether they earn more or less, they get no more spending money.

I recall a number of cases where I have been asked to intercede on behalf of the worker to show the parents the effect this practice had on their children, and how a more liberal supply of spending money would give their children greater happiness and the necessary incentive to do their best, and how as a result it would bring themselves more money and greater happiness.

Too Proud to Work

The fifth class are those who must work, but because of false pride will not associate with their shopmates and will often take roundabout routes to and from work so that no outsiders will know they work in a silk mill. I remember canvassing a certain city for help where the solicitor had the

door slammed in his face when he asked the mother whether she had a daughter looking for work. The solicitor happened to know the grocer who once supplied the family groceries, and learned from him that, while the family were too proud to work and make an honest living, they were not too proud to fail to pay a heavy grocery bill.

I recall another case where a girl was very irregular at work. As she was quite skilled, and we needed help very much, we decided to investigate her excuses for absence. We found that her mother supported several smaller children by taking in washings, and that in her opinion the daughter was absent simply because she was too lazy to get up in time.

One of the troubles in getting girls in a new locality is the feeling that it is a disgrace to work in a silk mill. Sometimes the school teachers are partly to blame. They use it as an argument to hold girls in school. At other times the superintendent and foreladies do too much bullying, or do not treat the girls with proper respect.

The problem of the human engineer is to find common principles with which to help the working young man and woman to a state of contentment and happiness in performing their task and doing it well.

Two men were viewing a sky scraper in New York City. Said one to the other, "I helped to build that building." "Were you the boss carpenter, or perhaps the boss mason or chief engineer?" "No," said the other, "I was a hod carrier." This incident illustrates the first principle upon which we will endeavor to find a way to bring happiness to the winder, spinner, doubler, etc., in a throwing plant; that is, by showing them that in piecing up ends or doffing bobbins they are making the thread, a very vital part of the beautiful fabric seen in finished hosiery and garments that adorn the woman of this age.

I have found that, when defects in hosiery and garments are shown to the female workers, they are touched with a sense of regret at the results of their carelessness, and that, instead of resenting and obstructing efforts at correction, they respond heartily, and show by their cooperation that they appreciate the vital part they have to perform. They realize that their

work must be done well, and they find contentment in the achievement of a beautiful and perfect fabric.

The first principle is the *knowledge of achievement.*

Fair Deal

The second principle will be found in giving happiness to our workers and giving them a *fair deal.* There is a tendency among mill workers to feel that someone is always trying to put something over on them by taking advantage in fixing piece-work rates or by cheating them in making up their pays. They dread iron-clad rules, and this causes a feeling of duress, which breeds a nervous and restless spirit and resentment which sometimes breaks out in a united demand and protest for relief.

To give a fair deal the foreman and superintendent cannot play the good fellow to the "good lookers" and the favorites in the plant, as that creates envy and jealousy among the unfortunate ones. Familiarity breeds contempt, and just as soon as a man becomes too familiar with his female employes he loses their respect, and they will court all the favors they can hope to receive.

Characters in forepeople and mill superintendents counts a great deal in acquiring respect. One must get the other party's point of view and the motive in back of his or her actions if one hopes to give a fair deal and avoid much unhappiness.

A good manager, however, will not only give a fair deal but will also demand it from others. Emerson says that the expression, "It is more blessed to give than to receive" is not impractical religious sentiment but the higher form of efficiency teaching, that what one most needs is the fair deal for oneself, and that the best way to secure it is always to give it. We may pay out a thousand cents in little fair-deal acts and apparently never receive any return, but suddenly one of those cents which has been drawing compound interest will come back as a twenty dollar gold piece.

He tells the story of a manufacturer whose heart was too big and tender and whose common sense was eclipsed by his sympathies. His factory was full of what his men called

charity patients; men and women were kept on the pay roll because they could tell an artistic "hard luck story." Wages were based, not on efficiency, but on the eloquence and pathos of requests for increases. Workers came and went about as they chose; every operation was timed to slow speed lest the unfortunate ones should fall behind and overdo themselves, and no strict account was kept of material because it seemed to hurt employes' feelings to be questioned too closely about it.

This kindly, well-meaning man was not loved by those he thought he benefited, but they held him in good-natured contempt—and robbed him generously and cheerfully. His receivers paid creditors fifteen cents on the dollar.

To give our employes a fair deal we must give them steady employment.

Steady Employment

If we hope to hold our help, we must give them steady employment. One of the great trials of a commission throwster is that his supply of raw stock is too often subject to delays over which he has no control. He must therefore let his help go for a day or more and then work them overtime to make deliveries.

The principal causes that bring about this condition are the following:

First, the great distance to the primary market of our raw supply.

Second, holding off in making contracts for raw stock in a dropping market.

Third, too great fluctuations in the price of raw silk.

Fourth, lack of a standard classification, causing rejections and delays in replacements.

Fifth, indifference on the part of the manufacturer, and tardiness in sending a fresh supply.

Sixth, spot business.

The increasing demand for thrown silk at call has produced a trade of considerable proportions in thrown silk. As the seller of thrown silk must take chances on the market, stand the waste made, and the interest on the stock carried, he must

ask a higher price. This is partly covered by selling silk on delivered weight, which includes the soaking gain.

This method also enables the throwster to keep his help employed steadily, and he therefore can maintain a higher efficiency of costs and quality of thread.

As we pay a higher price for promptness in railroad service and other accommodations, it is only fair to the throwster who is called upon to keep his organization in shape to give prompt services, that he may be rewarded for such services.

Health of the Worker

The third principle in giving happiness to employes to promote greater efficiency is found in seeking ways to promote the health of the workers.

One of the perplexing problems of a mill forelady and superintendent is to pass upon a request for a sick leave when the department is pressed for work, and when an absence will make it necessary to lay off other help who depend on the work and will affect the production. I plead guilty to prevailing upon help to stick it out and afterwards have found an occasional one who has been taken to bed with serious sickness for many weeks, much to my remorse.

Those accustomed to mill life will, however, not judge the boss too severely, as they possibly remember that they have been too frequently fooled by girls who feigned sickness to get an afternoon off, go joy riding, or partake in other pleasures. It is considerable of a problem for a man or woman not skilled in the medical profession to judge when a girl is really sick or only feigning. I welcomed the day when it became possible to engage a nurse who might pass judgment on all requests for absence on account of sickness.

Does the increased attendance and production per operative justify the expense of a nurse? I have no exact figures to offer, before or after, as conditions were so different that it was impossible to make a true comparison. However, when the help are encouraged to see the nurse at the beginning of a cold or other incipient disease, I have seen chronic absentees, whose

health was indifferent, restored to good health and regular attendance. Years ago I have seen a cold epidemic start in a department and eventually affect the majority of the force before it ran its course.

Spraying disinfectants on the floors, and timely suggestions to the help during epidemics of cold and grippe are very helpful and profitable. I am thoroughly convinced that a trained nurse in a fair-sized factory can be made to pay good dividends by reducing the turnover in help, by advising all new help, by reducing the number of absentees through preventive methods, and also by creating a more happy and contented worker. A half-sick employe is sometimes a very troublesome and cranky one. In small factories, one of the foreladies or a member of the office force could be trained to give first-aid treatment under the advice of a physician.

Must Prevent Sickness

The medical profession is striving more and more to prevent sickness among its patients, rather than to allow them to become sick and then cure them. Only when this principle is carried out in a mill organization will a nurse be a profitable investment. A factory nurse must familiarize and adjust her actions to factory conditions and recognize that her salary as well as that of the other workers is found in a full production, and that those given first-aid treatment should be sent back to work whenever possible. She must not cater to all the whims and slight aches that young people are subject to.

The need of proper first-aid treatment is illustrated by two experiences, one of them occurring during my early mill experience as office chief. A young woman fainted in the mill and was carried to the office, where we gave her a dose of whiskey to revive her. After she had recovered we sent her home for the day. The next day she fainted again, and we treated her the same way. The following day she fainted the third time, but her color was too good and aroused suspicion. A consultation was held, her character inquired into, and upon the information obtained the assistant superintendent said he would

administer an old-time cure. He took a towel, wet it under the spigot and slapped the girl across the face. That revived her very quickly and proved a sure cure, as she never fainted again. The second case is that of an assistant foreman who took sick. His superior sent to the drug store and got a "cure all" that came near proving fatal.

The most frequent complaint heard from the girls after being in the mill a few days is that they get too tired and that their limbs ache all over. Investigation showed that it is mostly the girls who wear high-heeled shoes at work that complain, and that when we can persuade them to change to low-heeled and comfortable shoes, when they arrive at the mill, they do not become overfatigued.

Poor Sight

A number of singles were discovered in spinning two threads. They were traced back to a 5B hand who was found to have only 50 per cent eyesight. She was given a leave of absence to get glasses and on return never had another single. Other help were examined by a specialist and a surprising number were found with only from 70 to 80 per cent vision. Some of them complained of constant headaches, others of nervousness—all of which was found to be due to eye strain, and was overcome with proper glasses.

Vacations

Twenty to twenty-five years ago, very few mill hands took vacations, partly because work was scarce then and those who had to work feared to be absent any length of time lest they lose their jobs. Besides, those who went to work needed the money for a livelihood, and, as their pay was only from $1.50 to $5 per week, they had very little to spare. Then only the superintendent and managers took vacations. Eventually the full-time workers, such as office help, foreman and foreladies, were given a week's vacation with full pay. Later, this was extended to ten days, and now two weeks appear to be the rule.

Gradually the help began to ask for vacations, and at first when business was good these requests were granted, provided

the applicants brought in other hands to fill their places while they were away. When business was poor, the help were urged to take a week or two off and leave what work was to be had for those who were dependent on the work for a living. In small cities and towns it is surprising how magnanimous some of the help were when they found out the actual needs of their fellow workers.

When the supply of help became scarcer in the states where they have only nine month's school, we started to take on learners the first week of school vacation, making a schedule of dates when different help wanted vacations, and preparing others to take their place. The first year our costs for teaching learners were excessive, but in the following years we got back many of those who had worked before, and the plan worked out without much loss in production.

Objections to Closing Plant

When manufacturers do their own throwing and can govern their raw silk supply and use, it is practical to close down the whole plant and all take a vacation at the same time. The objections I find to this plan are:

1. The loss in production can never be made up.

2. It is very unsatisfactory to the help, as young people generally want to join their parents during vacation time and the parents cannot always arrange their vacation when their children are free. This results frequently in some of the help receiving two vacations. If one refuses them the second vacation, they simply stay away; and, when they come back, one has the choice of giving them work again and building up production promptly, or of taking on learners and waiting several months before they become skilled, at a heavy additional cost to run the department.

3. At this time, about 70 per cent of the help take vacations. The others prefer to work, because it means a privation to them to lose their pay. When a general vacation is granted, the latter frequently go elsewhere to obtain work; and, if they like it, they do not return. The loss, however, is not

any greater than when the help take vacations at their own convenience.

Young people like change of scene, and they often take the opportunity when off on a vacation to try other jobs and stay away if they suit them. The effect of vacations on young people is very noticeable in their production per operator, and morale.

Following vacations one finds a marked increase in the production per hand. They are more amenable to discipline, and the morale is decidedly better. This appears to hold up until the Christmas holidays, and it is partly stimulated by the desire to earn all possible for Christmas buying. The week before Christmas and the week following Christmas are generally low in efficiency, due to apparent reasons. The efficiency then starts to increase and gradually reaches its height in March, April, and May. During the month of June it starts to lag, and reaches its lowest level during the month of August. The psychological time then to take vacations appears to be during the month of August.

Welfare Organizations

To what extent do welfare organizations help to break up the monotony of mill life and add to the contentment and efficiency of mill workers?

At mill F the ladies of the city organized a civic club, and decided to help the factory girls. They first proposed to have one or more of their number teach them common school studies, but were very much surprised to learn that a number of the girls were high-school graduates, and that all had a common school education. It was found that many of the girls were working only to furnish a "hope chest," or in order to dress better, and that they were eager to learn etiquette, fancy sewing, millinery, and dressmaking. They organized classes of that kind, had a large attendance, and closed the first season with a very successful bazaar.

Eventually it developed into a Y. W. C. A. The mingling of the factory workers with the society women of the city gave

both an entirely different impression of each other. This had an excellent effect in the mill and community.

Successful Associations

When I became associated with the Julius Kayser Co., at Brooklyn, N. Y., I found a welfare organization that had been in existence for 30 years, and a ladies auxiliary that had been giving relief to its fellow workers 16 years. The welfare organization provides sick and death benefits, and conducts social activities, such as dances, entertainments, and excursions desired by its members. The funds of the organization are secured from monthly dues of 30 cts. per member, contributions, and earnings through excursions and social affairs.

The sick benefits are: first week, nothing; second, third, and fourth weeks, $8 per week; fifth, sixth, seventh, and eighth weeks, $10 per week. No benefits are paid for more than eight weeks in any one year except in very needy cases. The death benefits are $100, secured by an assessment of the members. The association provides a doctor and his services are free to all its members. The officers serve without pay. The association physician is paid a nominal salary. The company provides a nurse during working hours, and a physician daily except on Saturday. A modern cafeteria is conducted, and lunch is served at cost. A retail store serves employees with Julius Kayser's products at reduced prices.

The ladies auxiliary investigates cases of employees in distress, and gives relief to worthy members. On Thanksgiving and Christmas they send out dinners to needy families, and furnish food, clothing, and flowers, as circumstances suggest. They receive their funds from voluntary contributions, entertainments, etc.

For one knowing the needs of his help and having their welfare at heart, it is very gratifying to pass on to a faithful employee, during illness, $8 to $10 per week, particularly when one knows that it is the only source of income the employee has. Such organizations replace the humanitarian service given, in the days of small factories, by the owners, who knew their help individually and personally contributed to their needs.

Operation Satisfactory

As I have had the privilege of serving a number of years as a director and officer of the Julius Kayser Welfare Organization, and as such have been able to study the inside workings of the organization very closely, I am pleased to say that I have only the higher words of commendation to express.

I have observed that, as the help pay for all the benefits received, they do not consider themselves subjects of charity, when receiving sick benefits, but only as receiving a return on their investment of 30 cts. per month in a mutual sick benefit organization. It creates a sympathetic feeling among the help that increases the morale of the group. As to the effect on the loyalty of the help to the company, I would say that anything that builds morale also increases loyalty.

I question, however, the wisdom of having minor executives dependent entirely on an employes organization for relief during illness, as that may tend towards loyalty to the help rather than to the company.

The welfare organization obviates occasional collection for sick and needy workers, and was originally organized to overcome this practice.

Should Owner Contribute?

Should the owner contribute toward sickness and death benefits when due to natural causes, and if so to what extent, or should these benefits be strictly controlled and supported by the employes?

Let us analyze the various factors bearing on this subject that appear in the throwing industry before I answer these questions. In large plants we find practically all of them in one mill, in small plants only some of them appear.

1. Throwsters as a rule employ principally girls and young women, the average service being from 3 to 5 years.

2. Throwsters, as in most all industries, pass on to operators the loss of time due to sickness, vacations, slack periods, and other causes.

3. While the average time of service is only from 3 to 5 years, there are a number who serve as teachers, become the pace makers, and remain and give 10 to 20 years of good service. If a company contributes to the general fund, and sick benefits are paid to the sick and unfortunate ones who may give only a few years of service, it appears unfair not to do something for the old, faithful, and loyal employees who seldom become sick, and whose services make possible whatever profits are earned. It actually puts a premium on becoming sick and taking a few weeks off at part pay.

4. As the throwing industry generally employs the cheapest labor in the community, it obtains a large part of its help from the laboring class, who live closer to actual want and sacrifice than do the workers in most other industries employing girls and young women. This class, by reason of environments, often stay with the throwster the longest. As they work side by side with others who only work for pin money in order that they may either fill in idle time waiting for a chance of another position, buy a hope chest and marry, earn money for a higher education, or take a coveted trip, any welfare work in a throwing plant presents a complex problem. Yet, if the employer extends the time of welfare service beyond, say, three years of service, it simplifies things and eliminates the undeserving class.

There are several classes of help that a superintendent who is concerned about the welfare of his help desires to reward. These are as follows:

First, those who are thoroughly loyal or refuse offers at seasonal work for higher pay, or those who inform the executive of labor trouble and act as peace makers.

Second, those who show initiative and suggest methods of improving the work, cheapening the cost, or increasing the production.

Third, those who are inherently honest and those who are always on time and regular in attendance.

Fourth, those, who because of illness in the family, become financially embarrassed and need financial help at a reasonable rate of interest or a loan with the privlege of paying it back in installments so as to avoid the usury of loan sharks.

Fifth, the pace-makers and teachers who, because there is no vacancy at higher positions, remain in the operating class.

Necessity and Benefit

Is welfare work necessary, and does the company profit by it?

My finding is that the need of welfare work in large organizations is greater than in small plants, because in the small plants the chief executive is more or less in personal touch with the help, considers their needs and requests promptly, pays them according to a mutual agreement for services rendered, frequently grants accommodations, and gives perquisites.

In large organizations, it becomes necessary to avoid favorites, limit the salary and wages, and keep after department heads to maintain efficiency. Cost sheets and production reports are studied very closely, rules and regulations that must be observed are more numerous, and there is a tendency for the minor executive to become formal and devoid of sympathy. When a problem arises, these executives apply the rule and do not always exercise common sense. Wage adjustments and allowances frequently must go through a line of minor executives. As this is sometimes done in a perfunctory manner, and furthermore as the changes are frequently not allowed, or are delayed, an acute situation is often created, and valuable help are lost.

We frequently hear the phrase "Corporations have no souls," and it appears necessary to put the "soul" back into our large organizations if one hopes to succeed in large industrial centers.

My firm conviction is, after seeing the benefits and appreciation of welfare work in different forms during a period of eight years, that it is not maudlin sentiment, but, when properly administered and given for specific services it can be made to produce an excellent morale, increase efficiency, and secure conscientious service, which means good work and more steady business at less cost through a decreased turnover in help.

Experience proves that something given for nothing, or gratuities, are not, as a rule, appreciated enough to warrant welfare work. One must not, however, let the acts of malin-

gerers, ungrateful help, and those desiring easy money dominate our actions, as these employes hardly represent 5 per cent of the help. We must investigate the other side and see the joy, happiness, and comfort that may be given to deserving employees and the loyalty promoted by considering the welfare services to the help.

In my judgment an employers' welfare service should be conducted distinctly separate from that of an employees' welfare organization, and the employees should be rated on years of service, loyalty, productive capacity, attendance, punctuality, and quality of work on a cumulative plan upon which the help can draw as desired.

The welfare services that may be given are benefits, in case of sickness or death; part or full-time pay during vacations; the privilege of securing loans at a low rate of interest; the services of a doctor and nurse at nominal rates; lunches at cost; and pensions at a retiring age. When the throwing department is part of a manufacturing organization, there might be added the privilege of purchasing the product at reduced prices.

To get the full benefit of welfare service it cannot be in lieu of wages. I desire, however, to emphasize the fact that large organizations working on standard products cannot maintain the peak wage rates paid by seasonal employers; but, where the help are offered steady work at a fair wage rate prevailing in the community, and then to this is added a welfare service, one can expect a hearty reaction from 95 per cent of the help.

To what extent do social activities within a mill organization increase the efficiency of a plant and make the routine workers more contented? It is generally known that young people are gregarious; that is, they delight to go and act in groups of their own kind. We find, in some throwing plants, as many as six nationalities and three religious sects. As most of them have mingled together in the common schools, we do not meet much animosity due to nationalistic spirit or religious beliefs. My experiences in social activities include excursions to the sea shore and parks during the summer, and minstrel shows and balls during the fall and winter months.

Usually, these activities were paid for by the sale of tickets to employees and friends. The time off in case of excursions was borne by the help, and the loss in production by the company. The excursions were patronized by about 60 per cent of the help, and, with what tickets were sold to friends and relatives, the attendance averaged about 85 per cent of the employees. Those who did not go were mostly those who could ill afford the loss of a half day's wages, and provide in addition a change of dress and a coveted lunch for the occasion.

At plant B, which was located in a town of about ten thousand people, excursions were run on Saturdays during prosperous seasons, the company paying full time and also the fare to all the help that attended the excursion. Tickets were, however, sold to friends; and, as there was a strong community spirit and the plant was a popular working shop, the sale of tickets was quite large and the excursions always a big success.

Promoted Good Fellowship

I have observed that all the outings promoted good fellowship, created a friendly spirit, and gave an opportunity for a social chat and a chance to meet many of the parents. They created a better morale in the plant, and also in some cases proved an advertising feature for help. My findings are that when the earnings of a plant are such that an outing can be afforded, it pays good dividends sometimes to shock the help and do a generous act without any strings attached to it. In the larger cities, since only about 33 per cent voluntarily buy tickets, it is proved that the help prefer to select their own amusements. When the expense of an outing is borne by the help, a way should be found to give a good time to those in the plant who know nothing but want and sacrifice, without adding an unnecessary financial burden or making them a subject of charity.

Dances held quarterly are patronized by only about 10 per cent of the help and their associates, principally sedentary operatives. Their helpfulness in giving relaxation from the daily grind of routine work, in my opinion, is of doubtful value.

My convictions are that no mill organization suffers any loss in efficiency or morale without them. If we stick to the job, study to avoid overfatigue, pay the help for actual work done without causing any loss in production or increase in cost, seek to find ways to guard and promote the health of the employees, and avoid unnecessary rules or keeping the help under constant duress, we promote and build up a stronger and more contented organization than by any number of social activities.

Strikes and Walk-outs

My experiences with strikes and walk-outs cover four department walk-outs and a number of threats, but no general strikes. These incidents are not advanced as general principles to be followed in handling labor troubles, but only to show different methods used from which one may draw his own conclusions.

At mill K the night force consisting of young men walked out and demanded more pay. As we were then only receiving 55 cts. per pound for throwing organzine, we could not advance wages and, at the same time, meet expenses. The leaders were discharged and the rest given a week's time to return as individuals. A few returned within the allotted time, but the majority decided to stay out in sympathy with the leaders who were discharged. A month afterward a number more applied for reinstatement, but it appeared necessary to keep them all out of the mill to prevent future strikes. Parents interceded for their sons, but we remained firm and did not reemploy any of them.

I was complimented by the general management on the efficient manner in which I had handled the walk-out and prevented a general strike at the plant. It required, however, nine months to build up the department and bring it back to the same efficiency as before the walk-out.

Two years afterward, with almost an entirely new force of help, the same department walked out again, but this time they carefully avoided a leader. I was keenly disappointed that my methods of handling the former strike had not prevented another.

Wanted More Money

My analysis of the trouble showed that the young men wanted more money; and, as there were a number of strikes in the various industrial centers of the country, the strike fever got into the men and they wanted the thrill and excitement of a strike. I had learned that the methods adopted in handling the first walk-out were considered decidedly autocratic and arbitrary in the community and that enemies had been made. I had found, also, that parents do largely control the actions of their grown-up boys; and had learned further that breaking in a new night force is very costly and disappointing.

I decided to handle this labor trouble differently and follow the principle used by a certain captain to conquer an enemy. A general sent out a captain with a company of soldiers to subdue an enemy. In due time the captain reported to the general that he had succeeded in conquering them. The general asked for the number of prisoners and the number of dead and wounded. The captain reported that there were no casualties, and that he had conquered the enemy by making friends of them.

We called the young men into a conference and told them that the condition of business and prices did not warrant an advance in wages and that they all could return to work as soon as the strike spirit was out of their systems. We visited the parents, explained the whole situation to them, and asked for their cooperation. Where the parents feared violence, we told them to keep their boys away from the mill until the danger was over. In two weeks' time all were back at work and during the next five years, or the extent of my supervision at the plant, we had no further walk-outs in any department. I desire to say, however, that we had to discipline a few agitators, build up loyal department heads, keep in close touch with the workers, and settle minor difficulties promptly and satisfactorily so as to keep the help contented.

Ninety-nine per cent of the discontentment and unhappiness in throwing-mill life is not due to the routine nature of the work, for most young people do not stay long enough to become "factoryized," but the disturbing factor is often a loss on piece

work or overfatigue caused by poor silk, and the resulting fight for what the help believe a reasonable allowance.

Disloyalty Troublesome to Correct

Disloyalty of the forepeople is sometimes the most troublesome condition to deal with and the hardest to get at and remedy. Having been workers themselves they are very sympathetic and quick to sense any injustice, and, while they openly dare not agree with the help, they too often look the other way when trouble is brewing and let it get beyond ordinary control before reporting it. Occasionally, one finds a forelady who has strong convictions and makes a strong plea for improvements in method, who requests changes in rates or asks for allowances on poor silk or other unusual conditions, and one wonders whether that forelady is loyal to the company or is more concerned about the help. But when one analyzes her plea and gets at the motive in back of it, one finds her actions quite logical and loyal, since 99 per cent of her troubles with the help are wage disputes. The help work for money and expect the pay to be uniform and hope to earn it without overfatigue.

The forelady knows that if the help are satisfied she can hold them, and that they will produce the full capacity of the machines and make good work. On the other hand, if the workers are discontented, the work is poor, and complaints and claims follow, so that instead of making a plea to maintain production, produce good work, and avoid claims, the forelady goes straight for the mark, tries to satisfy the workers by giving them a fair deal, and then demands it in return from the help. This is not the best method nor does it follow along conventional lines, but, as our foreladies are usually strong in common sense, seeing the essential thing and going after it, one must seek the motive in back of their efforts and look at the essential thing before passing judgment.

At plant D, two labor leaders entered the city and started to organize the help, demanding more wages and a cessation of the practice of fining. In three weeks' time they succeeded in getting one-seventh of the help out of the mill and into the

union. A meeting was arranged with the committee and an increase in wages was agreed upon. We agreed not to discriminate against union help, but permitted no solicitation of membership to the union during the working hours. As to the fines, we asked the labor organizers for a substitute to discipline the help, and they suggested a furlough or dismissal from service. As labor was scarce and production was urgently needed, we did not find that the hire, fire, and furlough method gave us the desired results. We eventually adopted two rates. A good service rate was given to those who obeyed the rules, were prompt and regular in attendance, and made good work with normal waste. The regular rate applied to help who were irregular and tardy in attendance, made only passable or poor work, and had excessive waste.

This method proved, during a 12-year trial, to be an excellent substitute for fines, especially so when the good service rate amounted to from 50 cts. to $2 per week higher than the regular rate, and when it was based on a progressive scale graded in proportion to the earnings and years of service, so as to give a greater reward to the oldest and most skilled help.

Now that we have concluded the general consideration of mill conditions, the supply of labor, the attitude of owners, the requisites of scientific management, the qualifications of executives, and welfare work with the problems involved in building up and maintaining a happy, contented, and successful organization, let us study some of the actual mill experiences and see whether the ideals outlined are beyond the reach of the throwster and are too lofty to attain, or whether they do promote the desired end and net efficiency.

We will first consider such incidents as call for human engineering. Since the incidents are actual mill experiences, for obvious reasons I will use fictitious names and change the incidents in minor details while giving the fundamental facts.

Wanted Old Part Back

At mill J, a 5B hand refused to take a part given her by the forelady upon her return to work after a week's absence on account of sickness. This girl insisted on having her old part,

and when the forelady would not grant her demand she appealed to me for justice. She said that she was one of the oldest hands in the mill, and was being treated unfairly by the forelady who, as she expressed it, was trying to put something over on her.

Upon investigation I found that feeling, more than anything else, was the real trouble. The girl was also balky and saw an advantage in getting her old machine back, since the part would doff out in 1 hr., whereas the machine offered her would not doff out for about 4 hr. As she had doffed out all the bobbins on her machine about ½ hr. before she went home sick, we decided that it would be unfair both to the company and to the hand who ran her part temporarily during her absence to give her the old part back at that time.

As I have found that there is such a thing as the human touch entering into the successful operation of a machine, I always aim to give back to the help a machine they have had before and have kept in first-class shape. The girl threatened to leave if she did not get her old part back, and as she was a very good worker, I decided she was worth making an effort to hold. I knew that the forelady was not trying to put something over on her, because I had instructed the forelady what to do.

If I yielded, I would do an injustice to the girl who had run the part during the regular girl's absence. The temporary girl had received the part with spare bobbins and would be giving it back with full bobbins with a benefit of about $2 to the other girl, and a similar loss to herself. I could have compromised by giving the temporary girl what was due her and putting the regular girl on day work, but that would have done an injustice to the company, and, in addition, established a precedent that others would have followed and also demanded when they found it to their advantage to do so. It was necessary, therefore, to remain firm and not at that time give back the machine desired.

Strong in Feeling

In seeking her motives, I found that she was very strong in feeling and in "won't powers" that morning, and therefore

I decided to harness her "won't powers" and win her back to a right way of thinking. I excused myself to give her a chance to cool off. After explaining that, since a principle of fair management was involved, we could not give her the machine that morning but would do so the next day provided she took what we then offered her, I told her that, if she walked out, we would send for a certain girl who had applied for work and who we knew was an enemy of hers, and give this girl the chance to earn $20 per week, while she went home nursing her stubbornness and lost time in hunting another job. She decided she would not give her enemy the chance, and took the machine assigned to her.

Possibly my readers have seen the picture of the darky who had trouble with a balky mule who was very strong in his hind parts or "won't powers" and was smashing things up in general but doing no pulling. The darky conceived and carried out the idea of hitching him up backwards, and the mule raced up the hill with the load apparently at a speed fast enough to break all traffic laws.

Are You Thinking?

The other factor in human engineering that was involved was that of feeling. Some years ago I clipped an article "Are You Thinking or Just Feeling?" from the *Philadelphia North American* which is so true to mill life that I give it in full:

Out in Cleveland is a big industrial plant in which the workmen and foremen, the foremen and department heads, and the department heads and the manager used to waste time in such constant and heated controversies as are common in nearly every enterprise of this sort.

Never a day passed without its quota of quarrels and long-winded wrangles—dealing mostly with matters of small moment, but wasting just as much time and temper as if the fate of the concern hung on each disagreement.

The owner of this plant used to scratch his head when he scanned the monthly balance sheets, and wonder why the business did not show better returns. According to all his well-based theories it should, but in fact it did not.

He knew something must be the matter. He tried to figure out what it was, but failed. He wondered if there was anyone who could diagnose the case and suggest a remedy.

At that time Columbus Austin Bowsher, a man past middle age who called himself a scientific phliosopher or something of that sort, lived in Cleveland. For several years he had been trying to interest business men in his charts and ideas.

His ideas were so different along some lines that he had almost as much trouble in making people see the worth of even a few of them as had another Columbus of whom history tells us. Some men said that his ideas were silly, while others just smiled and said nothing at all. In the meantime, Mr. Bowsher fitted up a little room in a big office building and plodded along in his effort to show men what he conceived to be their economic mistakes. Finally, he got a few hearers.

We have read some of Mr. Bowsher's writings, and are forced to confess that his mental processes are not always easy to follow. But that is neither here nor there.

One day the owner of the industrial plant mentioned was introduced to this scientific philosopher. They had a talk which wound up with an invitation to Mr. Bowsher to come out and visit the works.

Mr. Bowsher's Suggestion

That was the beginning of a long and mutually profitable acquaintance. Mr. Bowsher browsed around in the mill and listened to such bickering and backbiting as is going on most of the time in nearly every industrial establishment—in nearly every place where two or three are gathered together for the purpose of working, so far as that is concerned.

Then one day he stepped into the owner's office and made this suggestion: "The next time your manager comes in with a preconceived notion of some sort and wants to embroil you in an argument, ask him whether he is thinking or just feeling."

That was all he said, and the owner did not think much of it. But a day or two later, when the manager came in with a mental temperature of 110° in the shade and his fur up for a twenty-round verbal fight, the owner remembered what Bowsher had told him.

He let the manager blow off a couple of hundred pounds of steam, and then very gently said, "Are you thinking or just feeling?"

The manager looked at him and said, "What's that?"

"Are you thinking or just feeling?" repeated the owner.

The manager stopped talking and frowned. For a few moments there was silence. Then he smiled somewhat sheepishly and said, "Well, I never heard of such a thing before, but maybe I am doing more feeling than thinking in this case."

Whereupon he took to thinking, and within a few minutes the situation was cleared up.

Manager Begins to Think

That set the manager thinking. He went back to his office with a determination to try out this strange, new-fangled formula on the next overheated department head who came along. He did not have to wait long, and he almost failed at the crucial moment. It seemed such a silly sort of way to settle a dispute. But he tried it—and it worked.

The department head went off with a sort of haze enveloping his mental machinery. He wondered if he had been dreaming. But, like the manager, he thought he would try it out on an overwrought foreman. He did—and it worked.

That foreman passed it along to the workers under him, and the other foremen and workers got wind of it and began using it just for fun. Pretty soon the walls of the shops and offices were hung with placards bearing in large type the question:

"ARE YOU THINKING OR JUST FEELING?"

To make a long story short, thinking began to gain the ascendancy over just feeling in that establishment; and within a year, with the same number of men and the same equipment, the average output of goods increased nearly 10 per cent.

Now of course there is no warrant for saying Mr. Bowsher has hit on a universal panacea for the settling of disputes. We are not seeking to convey such an impression, but are simply telling a true story just as it came to pass.

We might add that when news of this curious happening began to spread in Cleveland, a number of smart men—some of them very big figures in the world of trade—smiled and said, "Bosh!" or the equivalent thereof—forthwith trying out the remedy the next chance they had and finding that it worked in most instances.

Editor Asks Question

We know of one instance where the managing editor of the country's biggest chain of newspapers went from Cleveland to Cincinnati to put a certain change in operation at the office in the latter city.

The local manager of the paper flared up and said there was no use in talking about such an innovation. He kept flaring until he almost foamed at the mouth. After he had exhausted all the expletives he could command, the managing editor said very quietly, "Well, Jack, are you thinking or just feeling in this matter?"

With that he walked out and took a train back to Cleveland. When he reached his office the next morning, he found a telegram on his desk. It read as follows:

"Guess I was just feeling. Change becomes effective today."

"That does beat everything," said the managing editor.

One of the men who ran into Bowsher in Cleveland was David Gibson, a writer and publisher, who does more than the average amount of thinking, day in and day out.

Gibson has seen so many impossible things proved easily possible that he did not smile as much as the others when he heard of this remedy. In the current issue of the *Public* he has this to say in regard to it:

"There are two ways of arriving at a conclusion: one is thinking about it, to arrive at it from a selfish point of view; the other is feeling about it, to arrive at it from the emotional, altruistic viewpoint. While the results may be the same, we have been feeling about our problems rather than thinking about them; and the individuals who really do the world's work change their minds and act more quickly and continuously in their selfish interest than from any altruistic or feeling motives.

"It took about 108 years to change the argument in favor of prohibition from that of pure moral feeling, to that of good economics—thinking.

"It is quite possible to think of many other great changes which lagged on the way until someone replaced their tired 'feeling feet' with seven league 'thinking boots.'

"And all the average individual has to do to get an appreciation of Mr. Bowsher's suggestion to the Cleveland mill owner is to give it a personal test the next time someone comes along to 'lift the roof.'

"So we pass it along for what it may be worth to individuals, groups, and communities."

Making a Pacemaker

At mill F, the foreman asked to be allowed to discharge "Red," who was constantly stirring up mischief in the spinning department. Red was a redheaded boy with just about as much pep and iron in his blood as his hair indicated.

I had singled out Red as a possible pacemaker for the night shift, and refused to discharge him. I called the assistant superintendent and foreman into conference, told them my plans, and asked them to cooperate with me in trying to harness his energy and if necessary to put up with some of his mischief as long as he did no actual harm.

I had timed the boy's speed, unknown to anyone, and found he could tend an increased part, so I instructed that he be given more spindles to tend. This procedure was so radical in the minds of the two minor executives that they were quite ready to and did predict what would happen.

I called Red into conference and told him what I had instructed the foreman to do, telling him also what confidence I had in him and that he must make good and not go back on me.

As Red had all he could do the next two weeks, he behaved fairly well and I was delighted, but when he acquired greater speed and again had spare time he got into mischief again, much to my grief and to the apparent delight of my assistant who was ready with "I told you so." We had another conference and we asked Red to take still more spindles as his speed showed he could do it. This time he refused, saying "What's the use? I get only half a dollar a week allowance no matter what I earn."

We sent for Red's father, explained the whole situation to him, and got his promise to give Red a percentage of what he earned. We called Red in and had his father repeat the same to him. We gave the boy an additional number of spindles to tend and he made good and kept out of mischief. Later on we put him on the night shift where he served as a pacemaker or as an example of what could be done, and, as a result, the whole department was brought up to a higher level of efficiency which fully repaid us for all the attention and patience given him.

Lessons Taught by Incidents

The lessons we may draw from these incidents are:

First, the importance of analyzing an employee and determining his qualifications or determining the material at hand to build upon.

Second, the need of exact information as to the speed of a worker and its relation to the spinning part he can do.

Third, that forepeople often act along the lines of least resistance.

In this instance, the foreman found that the easiest way out of his difficulty was to get rid of the mischief maker. The easiest way to do it was, in this case, to discharge the disorderly one. The fact that it had cost us considerable money to train him did not matter to the foreman, because he did not think that far.

Fourth, the error of the hire and fire method of permitting the forepeople to discharge the help.

It has been common practice in my supervision to move a hand into another department when a disagreement arises between the hand and the forelady. However, extreme caution is taken to do this before the situation becomes acute or the hand commits an overt act that necessitates his discharge.

My attitude is that as the turnover in a throwing plant is from 200 to 300 per cent per year, and, as it takes on the average three learners costing from \$50 to \$100 before they become skillful enough to replace an experienced worker, one can often correct a fault in an experienced hand more quickly, easily, and cheaply by proper handling than by going over the process of teaching a new hand, only to find him guilty of the same offense when he reaches that stage of experience.

Training a Beginner

When we take boys or girls into a throwing plant as learners or beginners, we must not only teach them to operate a machine, piece up breaks, and doff bobbins, but we must also teach them what a job involves, or the difference between going to school and taking things easy, and having a fixed duty to perform properly and within a given time. Generally their idea of work is simply to perform a certain task for which they will be paid a certain sum of money, which may mean a livelihood to some, and merely more spending money to others. After they have been taught the actual operations and are left to try them out

for themselves, they find the easiest and quickest way to do the work so as to get a rest or visit in the shop and chat. They do not grasp the idea that they should follow the rules and methods carefully, and watch their machine for possible imperfections and with a view toward improving the quality of the work. When they become skilled enough and are put on piece work, they no longer are interested in rest periods but seek the easiest and quickest way to produce all they can to increase their earnings. The quality is usually lower than when they are on day work because, in their hurry to produce, many imperfections pass through. Attempts to improve the quality by increased supervision are only partly successful. Constant watchfulness and reproof keep the help under duress so that only passable work is produced and the help show signs of resentment and indifference.

Education and moral suasion produce good results with help who have a moral foundation and a capacity to reason. Others know only the law of force and must be compelled to obey the rules by disciplining. When the supply of labor is short and the demand for capacity production prevents weeding out the undesirable help, one must resort to other methods to get results.

Quantity with Quality

Help do not go to work for exercise, but only for the money that is in it, and it would then logically follow that the more one pays, the greater should be the production and the better the quality of the work. This does not actually happen in mill practice. When help are on piece work, one gets a production per operative, generally speaking, in proportion to the pay; but, as they take the easiest and quickest way to do their work, their product is generally low in quality. However, when the rates of pay are based on both quantity and quality, they take not only the easiest and quickest way to do a certain thing, but also the best way, and only then is the highest efficiency obtained.

I find that two rates are necessary—one for ordinary service and the other for good service—and that when the difference between the two is great enough, and the work is inspected

properly, the ordinary workers become good service employees, the undesirable drop out, and the rating of the plant in point of quantity and quality is raised.

A skilled hard-silk winder ties up at the rate of about 160 ends per hour. The defects a winder makes are long knots, waste, looped ends, soft bobbins, crossed ends, and bobbins run up on end. The forelady can observe the soft bobbins and those that run up on end, but, as a winder ties up very quickly, a forelady cannot see even when she watches a winder whether the winder cuts the knots off short or long, or whether or not the thread is crossed, unless she draws the thread back off the bobbin. Increased supervision, then, does not insure good work, nor do high wages alone, but when one has the employees using the winder bobbins, or the doublers and spinners, to act as inspectors, setting aside all bad work and marking the number of the winder on the bobbins, and then sees that these are properly charged against the winder making them, and that the winder is paid according to the quality and quantity produced, then the highest production and best work is obtained at the lowest cost.

This method has been used in sections of the country where labor is cheap, and in other parts where labor is the highest paid in the world, and everywhere it has proved the most efficient method. I desire to state, however, that such a plan does not run itself but needs a constant supervision that not only gives but demands a fair deal.

Conscientious Forelady

In taking charge of Plant K, I found a very conscientious and unusually intelligent woman, whom we will call Jennie, in charge of the doubling. She had, at different times, had charge of every department in the plant, and was greatly interested in the welfare of the girls, hence a number of them went to her for counsel and advice. She boasted that she had full control over all the girls and that they would do anything reasonable for her.

After I had been at the plant one week she told me that the general manager had told her I was a first-class superintendent, but that during the week I had issued no orders, given no

instructions, and made no suggestions, and, as this was so different from what other new superintendents had done, that I had them all guessing as to what they might expect.

I replied that as the company had the reputation of being one of the best in the business, I wanted to study their method thoroughly before acting. After another week, in which time she became more familiar, she frankly admitted I was a curiosity and puzzled her; all of which I enjoyed immensely.

Of course she did not know that I was busy analyzing all the forepeople, making time studies with a stop watch in my pocket, and gathering speeds and other necessary information regarding the workers and machines.

I also waited for the forepeople and help to become accustomed to me—to get off their guard and act natural—and this I found could be done the quickest by overlooking any slight infractions of the rules.

To Maintain Production

Two weeks afterwards we received a large order for two-thread tram which meant a change from all four thread. There were idle doubling and spinning spindles, so I carefully laid my plan; pushing through the winding of the two thread so as to hold back on the four, in order to use the empty doubling and spinning machines and maintain the production. When the two thread reached the doublers I instructed Jennie to put on a part of two thread at once so as to hold back on the four as much as possible. I made no further suggestions as I wanted to see what the practice had been, and found that she gave the help the same part on two thread as she did on four. When I asked her if that had always been the practice she answered that it had, and was greatly surprised that I should ask the question. I then showed her that during the past two weeks, when she thought I was idling away time, I had found that at the speed the machines were running and the running quality of the silk, an experienced doubler could run 150 ends on two thread just as easy as 60 ends on four thread. I showed her that, according to the time studies, it did not take as long to tie up on two thread as it did on four, and that this was why they could run more

than twice the number of spindles on two thread at the same working rate.

I then asked her to increase the part to 120 ends and, as fast as she put on the two thread, to use up the idle machines so as to maintain the production and avoid blocking the winders. She told me that the theory looked all right, but she could not conscientiously ask the girls to do it as it was so unusual, and she feared they would object and walk out. I then kindly reminded her that she had boasted a week before that the girls would do anything for her and I now proposed that she give a practical demonstration of it. I told her that as a forelady she was the key woman and represented the help to the company and the company to the help, and that she must not only give the help a fair deal but also not forget that she owed a fair deal to the company.

Girl Makes Trial

Eventually she saw that she must at least make a trial, and soon found one girl who would make the experiment. When both she and the girl found that I was right and that the doubler had more spare time running 120 ends on two thread than 60 on four thread, the battle had been won, and the other girls followed on parts of the same size.

The management had expected to find a drop in the production when the weekly statistics reached the office, but, when they saw a full production, they made it a point to inquire as to how it had been accomplished. They were so well pleased with the results and the way it had been attained that I was instructed to proceed and put the whole plant on a scientific basis at a higher wage scale.

A change in lots on the winder found one lot of poor winding qualities, winding production decreased, and the doublers running low on silk. Jennie offered to take charge of the winding and show me what she could do to keep the doublers going. I agreed to shift foreladies and give her the chance. Two hours after the change was made Jennie had all the ends running and boasted that she would soon have enough silk. This was done by slowing down the speed 33 per cent. I then showed

her what the real capacities of the winders were at both 160- and at 110-thread speeds, pointing out that even with 10 per cent of the ends idle at the 160-thread speed, the production was greater than with all ends running at 110. She could not see it that way and wanted the chance to try her method for a few days to prove that she was right.

Old Speed Resumed

I gave her another day's trial and showed her that the supply ahead of the doublers had dwindled to practically nothing, and that she was losing ground. She was willing to admit this now. We then went back to the old speed. I called the help together, told them what had been done and why, and that we would now count their ends every hour to see who was the best worker. I also promised that, as a reward for carrying out the experiments which we would ask them to make for us during the next three weeks, we would give them a chance to earn more money at the beginning of the following month.

The counting of the ends showed that some of the girls at the same pay kept 40 per cent more ends going than others, and it was found that they were tying up at the rate of from 80 to 140 ends per hour. I showed Jennie how unjust such a method was, and how we could easily raise the wages by setting the higher rate at the 140-end basis (see later section on Working Basis). The final result was an increase of 60 per cent in wages at no increase in the average winding cost.

Jennie was greatly depressed for a few days, but, as I kept her busy making break tests and gathering other data for the proposed advances, she soon fell in whole heartedly with the new plan and helped carry it through to success.

One of the troublesome things that happened was that some of the best friends of Jennie were slow workers. They wanted more pay, but did not care to make the effort to acquire speed. These girls eventually dropped out causing many a heartache, but, as every girl had the chance to accept a small part at small pay or a large part at our advance in pay, and since Jennie did not force them, it was altogether up to the winder as to whether she made more money or not.

Jennie agreed that it was unfair to the company and to the other girls to give certain girls allowances, because she saw that allowances could not be made without showing favoritism. I pointed out to Jennie that one might be conscientious in such matters and yet act unfairly, and that an enlightened conscience and common sense were safer guides than sentiment or feeling.

Paid by Week

My first job as superintendent was in my home town where several of the workers were neighbors' daughters. When I took charge of the plant the help were paid by the week and their rates were determined by the forelady. Some of the girls, I discovered, worked faithfully until they got the maximum rate, and then worked more leisurely and blamed the silk when they did not keep their part running. As the girls played together, the forelady had no way to prove them wrong.

I introduced a rating system, where the part that had to be kept running so that the worker would receive the maximum rate, was found by counting the breaks. This will be more fully explained in a later section. The ends were counted every hour.

The help were given due notice that 4 weeks' time would be given them to acquire speed, and that after that time they would be rated according to the number of ends kept running. The first pay after the new system started revealed many surprises, one being that a neighbor's daughter received a lower rate than she formerly had. When this girl took her pay home and showed the reduction in rate, her mother called upon me and told me what a fine neighbor I was, that she thought I was a friend of theirs, and that she was going to take her daughter out of the mill. She said that her daughter told her that she spent quite some time each day in the rest room praying for me and yet I was just as mean as could be.

Convincing Girl's Mother

I got the girl's rating record, showed her mother the number of ends she kept going hourly, and compared them with what

other girls ran and their rate of wages. I tried to make her see how unfair it would be for me to rate her daughter the same as the others who ran many more ends, but she was not impressed. I then compared her daughter's record with that of a girl who had been in the mill only a few months and had kept less ends running than had her daughter. I changed the rate to the same as her daughter's and asked her if she considered that fair. She acknowledged that it was not and that it only showed how unjust I was, upon which I got the payroll book and showed her that the other girl actually got less than her daughter. Then she was satisfied.

I then took the occasion kindly to show the mother that apparently if I answered the girl's prayer, I had to cheat the company, show favoritism to her daughter, and that I did not think it very consistent of her daughter to leave her work to pray and still expect the company to make up for the time lost, while other girls stayed at work and kept their ends running. Before the mother left both she and the daughter had a different viewpoint of mill life. I pointed out that while in her home life, she, as a mother, could take the burden of the work and make life comfortable for her daughter, when her daughter entered a public works, the girl must only expect a just and equitable wage according to the work performed. She thanked me for showing her how wrong she was, and the daughter admitted that I had played fair. The next pay the girl earned an advance and soon reached the maximum rate.

This incident shows how that religious and conscientious help may have a very erratic conception of fairness, and what strange prayers their God must listen to. That girl got her answer "full pay" all right, but in a different way than she expected.

Increasing Spinner's Part

Plant J was a large organzine plant that was being started in a new locality. The second-time spinning part, in charge of John as foreman, had reached six machines, and our studies showed that with the average number of breaks which had appeared on the last six lots an experienced spinner could run nine machines.

I discussed the plan of increasing the part with the assistant superintendent and foreman, but I found them definitely opposed to a change in part, and they gave as their reason that the help could not keep up the ends. I tried to convince them with the facts gathered, but they said that while figures might show it was possible, it would not hold out in practice. I saw that any further argument was a waste of time, and told them I would deal directly with the hands. I asked them to stand by and watch results.

I went to Maggie and asked her how the silk ran.

She replied, "Very good."

"Are the doubler bobbins all right?"

She answered in the affirmative. I then asked her if she had much spare time, and when she replied that she had some, I asked her if she could run more machines. To this she replied. "Yes, if I'm paid for it." I told her we would go fifty-fifty, and she agreed. I then asked the other experienced spinners and they said that if Maggie could do it they could too; so the foreman received the order to change the parts at once. We increased the wages 25 per cent and the part 50 per cent. The help kept the part going without overexerting themselves, and they made a good record on production.

A few months afterwards, John the foreman was changed to the 5C department and Maggie got into trouble with him. He appealed to me to discipline Maggie. I heard both sides of the difficulty, and before Maggie finished her story of the grievance against John, she told me that he had asked her and the other girls not to take an increased part on second-time spinning, telling them that if they kept those going we would then make them run more. John denied ever having made such a statement, but Maggie had witnesses to prove what she said, and it looked bad for John.

Foreman Retained

Of course John deserved to be discharged, but he was a first-class mechanic and had given us excellent service on both the doublers and spinners, and, as everything passed off without any trouble, I told him that I believed what the girls said but

that I would forgive him providing that he now asked the 5C boys to increase their parts from three to four and one-half machines, and instructed him to start at once with his son who was working in that department. The part was increased on a fifty-fifty basis, and higher pay was given for good service, which was an incentive to the help to produce first-class work.

The experiences with Jennie and John show two opposite types of forepeople. Jennie, a loyal, conscientious, and responsive type, who, when she saw her duty clearly, entered heartily into the plans, and helped the girls to earn more money, without overexertion, by a fair method of rewarding actual services rendered. John, while he understood the mechanical processes thoroughly and worked hard and loyally to get the equipment into proper shape, had no sympathy for his help, and objected to the increased part. It was afterward proved that he objected only because he feared that his duties as foreman would increase. He was more concerned about finding the easiest and quickest way to perform his own duties than he was in decreasing the cost and increasing the earnings of his help. He was of a decidedly disloyal type.

An amusing part of the incident afterward developed when John took every occasion of visiting officials to impress upon them how he had built up both departments.

These two incidents also show how, with exact information at hand, one acquires confidence to push matters through to a success, overcoming all kinds of hindrances and disloyalty, and is able to succeed and prove the merits of scientific management.

Cost of Teaching Learners

In a large textile center we had a heavy turnover of help in the winding department. It required four learners to make one experienced winder at a cost of $100 each. Our wages were from 30 to 50 per cent above our competitors in Pennsylvania towns, but about 25 per cent under the seasonal rates of rayon winders in the same city.

Applicants at the rayon plants were instructed to go to our plant to be taught, and then come back to them and

they would give them work. When we were in a humorous mood we took that as a compliment for our thoroughness in teaching.

As our winding costs were already too high, we could not make a horizontal advance in wages and meet the seasonal wages of the rayon winders, but as our analysis showed that we lost too many experienced winders we decided upon a progressive scale of good service rates, giving an increase of from 5 to 10 per cent, depending on the amount of waste made, attendance, and punctuality. After the acute period of teaching was over, the cost dropped 25 per cent per pound, and our older help remained.

What response can one expect from help for giving them a fair deal and seeking to make them contented and happy at their work? In a new organization about 75 per cent respond voluntarily, about 15 per cent can be taught to react to kind treatment, and 10 per cent must be forced to respond or be dismissed from service. In older plants about 95 per cent are responsive, and about 5 per cent are always looking for an opportunity to gain an advantage for themselves or make easy money, and do not react to kind and fair treatment unless it affects them favorably. In such instances one must demand it, or weed them out of the plant.

The great mistake one is liable to make is to permit the misdeeds of a small percentage of undesirable help to prejudice a superintendent against all his employes, to put the whole department *under duress*, and make them nervous and restless, and often to frustrate plans for improvements that promote contentment. A better method is to investigate carefully all labor trouble, trace it to the source, and discipline only the offenders.

Securing Discipline

Should forepeople discharge the help in order to secure discipline? I would answer decidedly, "No." That should be the duty of the assistant superintendent in a large plant or the superintendent in a smaller plant. I am firmly opposed to the hire and fire method, as I have found that forepeople will, under

the impulse of the moment, discharge a good hand and afterwards regret their hasty action.

I can recall many instances where the forelady could not get results from a hand, but after moving the hand to another department he gave good service. Sometimes the help hold a grudge against the forelady and go the limit to annoy her, and the forepeople do not have the tact or patience to win back the respect of the help. I find that the best plan is to have the forepeople keep the superintendent informed of the minor offences and to shift the offender to another department before the offence becomes acute and requires drastic action.

Learners these days cost from $50 to $100, depending chiefly on the wages paid, and, as the turnover per year with young people is about 300 per cent, it is an expensive and faulty practice, when building up a new organization, to fire help for slight offences or because they cannot get along peacably with a forelady, especially when one has need for help in other departments.

In employing boys and girls, one cannot observe an iron-clad rule not to reemploy a hand who has left or been discharged. For a great many reasons, young people do not stick at work as well as grown-up workers, but one cannot force them to stay at work by such rules as apply to older help. I find that many of them come back to work again after a few months' absence, and often make very steady hands. About one-third of the help employed in a throwing plant are repeats—that is, those who worked for a while, got tired of it, loafed for a few months, and then tried it again.

I do not mean to encourage floaters. One must discriminate between employing floaters and those who leave for a good cause and then come back again after that condition has been overcome.

PART III

WAGE PAYMENT SYSTEM AND PRODUCTION

In the silk-throwing industry the work that is usually performed by efficiency engineers in large organizations is generally performed by the superintendent, where such work is done.

It is not my desire to intimate that every superintendent should be able to qualify as an efficiency engineer, as very few superintendents have the opportunity to get the training necessary, but rather I desire to point out to those having a textile and engineering training a field of work that challenges their best endeavors, and which I propose to show should logically follow a scientific grading of raw silk. It appears not amiss, however, to point out how a superintendent can enhance his usefulness and value to his employer by following scientific methods and acquiring exact information about his line of work.

Studies in Winding

The winding costs in a large plant were constantly increasing, under a weekly rating system, due to a continued need of help and a constant demand for more wages. Help worked diligently until they reached the maximum rate and then blamed the silk when their ends were down. The forelady played favorites, and as the favored ones fooled the forelady and assistant superintendent as to the working qualities of the silk, it helped those in disfavor to get away with it also, as the executives had no other way of judging the running qualities of the various lots.

To remedy this condition, a piece-work system was introduced; the wound silk was weighed on bobbins, and the winders were paid a price per pound, fixed according to the working qualities of the silk as judged by the forelady and assistant superintendent. When the help worked hard and exceeded a predetermined limit, the rate was cut. As the help were wise

to this, they fooled the rate fixers as to the running qualities of the silk, until the price per pound had been announced.

This method increased the average winding cost beyond that of the weekly rating system. To overcome this, an average price per pound was then adopted and when the winders could not earn a fair wage on poor winding lots, an allowance was made.

The forelady again played favorites in making allowances; others also demanded allowances on poor winding silk, which led to constant trouble and arguments about pay. The winding cost remained about the same, but the help earned more wages. Later on, when I was given the supervision of a small throwing plant, I set for myself the task of correcting these abuses and endeavored to give to the company a fair deal while rewarding the winders according to the actual amount of work done.

Determining Breaks

My first studies were made to find a method of determining the number of breaks in a skein without winding the whole skein. It was decided that these breaks must show the relative winding qualities on every class of silk; such as Japan's, single and double skeins; Canton's, Italian's, and Tussah's. It must include the breaks due to gums, fine ends, loose ends, knotted places, and ringy reels.

A series of 74 tests showed that the average break for the first hour was 33 per cent more than for the second. This was not a general condition, but varied from 20 per cent minus to 100 per cent plus.

Lengthy studies showed that a tolerance of 20 per cent from the actual breaks in the whole skein answered all practical purposes, as the help absorbed that difference in winding. This result was attained by winding 60 skeins until 10 per cent, or 6 skeins, ran bare.

Thirty skeins were put on the swifts with the under side up; and thirty were put on as they came. The breaks were counted from the start until the sixth skein ran bare. The speed used on $^{13}/_{15}$ denier silk was 167 yd. per minute, called *thread speed.* The breaks were based on 300,000 yd. and, at 167-thread speed, they were determined by multiplying the breaks

per spindle hour by 30, thus: Time of test run, 4 hr.; thread speed, 167 yd. per minute; total breaks on 60 skeins, 360.

$$\frac{\overset{\text{(Total breaks)}}{360}}{\underset{\text{(Time run)}}{4\text{ hr.}} \times \underset{\text{(Number spindles)}}{60}} = 1.50$$

1.50 × 30 = 45 breaks per 300,000 yd.

The factor 30, which is the number of hours required to wind 300,000 yd. on one spindle, was determined by multiplying the thread speed (167) by 60, obtaining 10,020 as the yards per hour per spindle. To wind 300,000 yd. on one spindle would then require 300,000 ÷ 10,020 or 30 hr. Thus the breaks on one spindle for 1 hr. × 30 equals the breaks on 300,000 yd.

Breaks Increased

During our first experiment, we recorded the breaks per hour. At an average thread speed of 167 yd. per minute, an organzine spinner bobbin with a barrel of 1⅜-in. diameter and a head of 2⅛-in. diameter starts out on an empty barrel at 130 yd. per minute and winds at the rate of 200 yd. per minute when full. It was found that by reason of the greater number of yards winding each hour, the breaks were increased 8. As the average Japan skein, at 167-thread speed ran 4 to 4½ hr., and the bobbin took about 3⅓ hr. to fill, it was found impractical to base the breaks on a time unit.

As the yards per pound varies with the size, as will be seen from the following table, and, as it was found desirable to reduce the variable factors to the minimum, it was decided to

Denier, Single Thread	Yards
1	4,464,331
9/11	446,537
10/12	405,895
11/13	372,093
12/14	343,438
13/15	318,922
14/16	297,672
15/17	279,048
16/18	262,638

base the breaks on 300,000 yd. and call these breaks the winding count. The table on p. 129 shows yards per pound of single thread, based on average size.

Most Efficient Thread Speed

Studies were then conducted to determine the most efficient thread speed. As the bobbins, spindles, and skeins vary in size, the number of yards wound per minute was found to be the only uniform speed unit. This may be determined approximately as follows:

1. Reduce the circumference of the standard American skein, which is 58 in., to yards: thus $58 \div 36 = 1.61$ yd.

2. Find the revolutions of the swift when the bobbin is half full, and multiply this by the circumference of the skein: thus, r.p.m. of swift (103) $\times$ 1.61 = 167 yd. per minute. The theoretical speed may be calculated from the speed of the main line shaft as follows:

Columbian Winders with Organ Winder Bobbins

Main counter shaft, 307 r.p.m.
Cone pulleys, 6, 5, 4, and 3 in.
Diameter of friction roll, 4½ in.
Diameter of spindle head, 1¼ in.
Diameter of bobbin head, 2⅛ in.; circumference 6.67 in.
Diameter of barrel, 1⅜ in.; circumference 4.32 in.
Half-full bobbin or average, 5.50 in.

Speeds	Cones	Speed of friction wheel shaft	Spindle speed	Thread speeds		
				Maximum	Minimum	Average
1	3 to 6	153	552	102	66	84
1½	4 to 6	204	734	135	88	112
2	4 to 5	245	881	163	106	134
2½	5 to 5	307	1,105	204	132	168
3	5 to 4	383	1,378	255	165	210
3½	6 to 4	460	1,656	306	198	252
4	6 to 3	614	2,210	409	265	373

Our studies showed that with an organzine spinner bobbin, at an average speed of 210, the number of breaks increased 7 per cent due to an increase of the thread speed to 255 yd. when the bobbins were full. When the maximum speed was reduced to 230 yd. there was no increase in the number of breaks. When the maximum speed without weights was reduced to 180 yd., there was a less number of fine ends broken out, but, as the number of breaks in spinning was increased, due to these fine ends left in the silk, no real gain was effected by winding at a lower speed. On gear swifts, the breaks increased when the maximum speed exceeded 185 yd. per minute. This is caused by the increased tension due to the weight of the swift.

The winding count was then used to determine the part or number of swifts that had to be run on each lot to earn the maximum hourly rate on winding. Others were rated in proportion to the number of swifts kept running. This method reduced the winding cost per pound, but, as the part was based on the speed of the average worker, the most skilled help had spare time which they wanted to use to earn more money.

Human Element in Winding

A series of studies was then made on the working speed of different winders, and was carried on for 5 years to determine the fatigue factor, the effect on the health of the winders, and the influences that home life, hours of rest, and vacations had on their speed endurance. We also desired to know whether it was necessary to hold back the speedy ones to keep them from overexerting themselves and setting too fast a pace for the other help.

Among the skilled workers we found a variation of 25 per cent in speed. Those showing the greatest speed displayed the least sign of fatigue because the work became so mechanical to them that little mental effort was required and practically all the work was done by the sense of touch without much conscious effort.

The production per operative was found to be the lowest during the months of July and August, picking up after the summer vacations and reaching the maximum just before the

Christmas holidays. It generally dropped during the holidays and started to pick up again the second week in January, gradually increasing and reaching the peak in March and April. As soon as the warm weather began, the operators started to slow down and reached their lowest efficiency in August.

Our studies showed that new help or learners on winding tie up at the rate of from 30 to 60 ends per hour within a week's time. In three months' time they acquire a speed from 90 to 120 ends per hour. In one year's time the most apt help reach a speed of from 160 to 180 ends per hour. However, a great number never reach a speed higher than from 120 to 140 ends per hour.

Speed in piecing up is dependent partly upon the skein formation. On the standard American skein (open diamond), it is the highest; on the straight skein or very small diamond, it is about 20 per cent lower. On skeins having a great number of fine ends it averages 10 per cent lower, as it requires more time to find an end strong enough to tie on to, and to draw the thread from the swift and wind it onto the take-up bobbins.

It was found more efficient to have the winders put on their own skeins (called skeining or dandering), as it gives them a change of motion and brings different muscles into action. Besides, when they wind their own skeins, they are more careful in putting them on the swifts than are the skein girls who are employed to do that part of the work.

We found that the highest speed could not be gained by driving the winders, nor could it be attained for an only nominal reward, but that wages had to be equal to those paid for similar service in the community.

Encourages Inefficiency

I do not find that a minimum wage rate in the throwing industry is advisable, as it encourages inefficiency among the learners, since some of them are contented to continue at the learner's rate, when they are high enough.

Experience shows that the help prefer a constant wage rate to a fluctuating one on piece work, as they budget their earnings very closely, and when they run under their average and cannot

meet some of their obligations it makes very discontented workers.

My conviction, after many years of close observation and a study of all the conditions involved, is that every worker should be treated individually, and should be financially rewarded according to his or her merits; and that it is an injustice to hold back skilled workers to accommodate the slower help. Rather in fixing a rate or basis of work, good judgment, and common sense must be exercised so that it will be based on a standard that the average skilled winder can reach without becoming overfatigued when winding at that pace. When one or more winders do exceed the standard and honestly earn it, the rates should not be cut, as it will arouse discord and provoke trouble. I find it highly efficient to have a few highly skilled workers as it incites others to do their best.

Scientific Wage Rating

Studies were then pursued to find the most scientific method of rewarding winders for actual work done—a reward which would be the greatest incentive for them to do their best in the easiest and quickest way. We found that when paying by the pound and arriving at the weight by weighing the silk wound on bobbins, the weights were subject to changes from 1 to 3 per cent due to atmospheric conditions; light and heavy soakings from 2 to 4 per cent; light $^{13}/_{15}$ and heavy $^{13}/_{15}$ or from 13.50 to 14.40 deniers, 6 per cent.

In six months' time these variable conditions averaged up, but, as sometimes they had a way of happening all in one lot adversely to the help, they caused labor unrest and a feeling that somebody was taking advantage of them. The workers could not understand explanations of the hygroscopic and physical properties of raw silk and their only care about it was how they could recover the loss in wages which they believed were earned—an opinion based on how hard they worked.

Methods that need constant allowances are not ideal and are never satisfactory to anyone concerned. This method required the service of a clerk to weigh the bobbins and keep

a record of the same. There was trouble in adjusting the silk left over on machinery when help was absent and others were put on the part.

The second method investigated was that of paying by the number of skeins wound. The objection found to this method was that dishonest help passed on to others a number of skeins when the other help and forelady were not about. It suggested cutting off rings or bands to increase the number of skeins wound, and caused excessive waste. There was difficulty in adjusting the number of skeins when help was absent for sickness or other cause.

Determining Winding Breaks

While these investigations were under way, the need arose for a shorter method of making a winding count for use by a chain of plants as a basis of winding piece-work rates, and for making uniform reports on winding qualities to the main offices and customers.

Experience showed that any short method that agreed within 20 per cent of the breaks on the whole skein, on all classes of silk, would answer all practical purposes, as the help could absorb that variation in their speed of working. The following short method met the tolerance of 20 per cent, and was adopted. It has been used extensively for the last 17 years and found satisfactory. Occasionally it was necessary to make a second test on a 10-bale lot, due to changes in one or more bales in the lot.

(Further studies on winding may be found in "Raw Silk Properties, Classification of Raw Silk, and Silk Throwing" by the same author, pp. 58–66 and 77–78.)

Skein and Air Conditions.—The temperature of winding room shall be from 70 to 75° F., at a relative humidity of from 70 to 75 per cent. The skeins shall be in or near a normal condition, or have from 11 to 13 per cent moisture.

Swifts.—Twelve-stick, pin-hub, unweighted swifts are preferred.

Speed.—The speed on soaked silk shall be, on $^{12}/_{14}$ denier and over, 180 yd. per minute when test is half completed, or

near the average speed used in winding. On sizes under 12/14 denier, use 140 yd. per minute.

Sampling.—Select 20 skeins from different parts of the bale. Avoid cut or tangled skeins in test.

WINDING TEST

Lot *56* Date *Jan. 1927* Name *W. P. S.*

Stock and Grade *JAPAN* Bale No. *287560*

No. Ends Tested *20* Thread Speed *180*

Time — Starting Time Started *9* Stopped *9:15* Time *15*

Time — Winding Test Started *9:15* Stopped *10:39* Time *84*

Remarks:

BREAKS: Starting Run Don't Count These Breaks	Breaks: Winding Test, Count These Breaks	Summary
Short fine	*~~////~~*	*5*
Long fine	*/ / /*	*3*
Broken threads or loose ends	*~~////~~ ~~////~~ ////*	*14*
Bad reel or tangled skeins	*/ / /*	*3*
	First End	*8*
	Double Skein	—
	Count Total	*32*

Fig. 8.—Sheet filled out by winder making test.

Method of Making Test.—First, rub out gums or reel markings. If they are hard like Chinas, then they should be rubbed out while the silk is still damp. Skein up 10 skeins with the under side up and 10 skeins as they come (regular). Make a starting run of 15 min., but do not count the breaks; then wind 300,000 yd. counting all breaks. At 180 yd. per minute on 20 skeins it takes 84 min. to wind 300,000 yd. The sum of

the breaks on the 300,000 yd. wound, plus eight, gives the winding count.

(Eight breaks are added to the breaks on 300,000 yd. to include the first ends tied up, and aid in computing an accurate waste and winding swift table.)

Figure 8 is a reproduction of a winding-test form sheet.

COUNTING END RATING METHOD

To overcome the faults named in the pound piece-work system, weekly rating methods, and paying by the skein, the following counting end rating system was adopted, and has been successfully used for 20 years, and has proven the most efficient method.

First, determine the winding count, or the breaks in the skein, by the short-test method. This can be made in the laboratory or in the winding room by a skilled and conscientious winder.

Second, determine the speed of the winding machine that will give the desired thread speed, as follows:

(This need not be exactly 180 yd. per minute, for some speed near to that will answer as long as the time run is changed accordingly.)

Atwood Winders with Spring Spindle

Motor: 10 hp., 110 volts, 81 amp.
Driving pulley: 9-in. diameter, 650 r.p.m.
Main shaft: 32-in. diameter, 266 r.p.m.
Cone pulleys on shaft: 7.0625, 6-, and 5-in.
Cone pulleys on machine: 6-, 5-, 4-, and 3-in.
Diameter of friction roll: $4\frac{1}{2}$-in.
Diameter of spindle head: $1\frac{1}{4}$-in.
Diameter of bobbin head: $2\frac{1}{8}$-in.; circumference 6.67-in.
Diameter of barrel: $1\frac{3}{8}$-in.; cir. 4.32-in.
Diameter of half-full bobbin or average: 5.50-in.
Traverse: $3\frac{1}{2}$-in.
Silk on even, full bobbin weighs 14 lb. and measures 42,000 yd. on $14/16$ denier silk.

Speeds	Cones	Speed of friction wheel shaft	Spindle speed	Thread speed		
				Maximum	Minimum	Average
1	5 to 6	221	795	147	95	121
1½	6 to 6	266	957	177	115	146
2	6 to 5	319	1,148	212	138	175
2½	7 to 5	372	1,339	248	160	204
3	7 to 4	465	1,673	310	200	255
3½	7 to 3	620	2,232	413	267	340

Third, find the number of swifts that a winder can tend at the different counts. To do this we must consider the time required to perform each operation in winding as follows:

Doffing: 1 bobbin—0.10 min.
Filling up: 160 ends per hour or 1 end—0.375 min.
Skeining: one skein—0.80 min. (based on average Japan skein running 4½ hr.).
Time based on a 9-hr. working day.

MULTIPLYING FACTORS

Doffing.—If one winder bobbin holds 42,000 yd. at 210-thread speed, one bobbin fills in 3.33 hr., or 2.70 times in a day of 9 hr. If one bobbin takes 0.10 min. to doff, and they fill 2.70 times a day, each spindle requires 0.10 × 2.70 or 0.27 min., which we call the spindle multiplying factor.

Piecing-up.—An experienced winder can piece up at the average rate of 160 ends per hour. One break takes 1/160 of 60 min., or 0.375 min. Silk showing 17 breaks on 300,000 yd. will show 0.000057 breaks on 1 yd., and on 113,400 yd., the production of one spindle in 9 hr., will show 113,400 × 0.000057 breaks or 6.46 breaks. If one break takes 0.375 min. to tie up, the 6.46 breaks will take 6.46 × 0.375, or 2.42 min., which we call the piecing-up multiplying factor.

Skeining.—The average Japan skein runs 4½ hr., and on a 9-hr. day must be replaced twice. One skein takes, on an aver-

age, 0.80 min. to skein and tie up without rubbing. As this must be done twice a day, the skeining factor for each spindle is 2 × 0.80 or 1.60 min.

		Minutes
Summary:	Spindle factor	0.27
	Piecing factor	2.42
	Skeining factor	1.60
	Total	4.29

If one spindle on count 17 in a 9-hr. day takes 4.29 min. to attend, a winder can tend as many spindles as 4.29 is contained in 540 min., or 125 spindles, for which we have the following:

C = average count of table.
0.27 = spindle multiple.
TM = total spindle factor.
540 = 9-hr. day basis.
113,400 = production per spindle per 9-hr. day, in yards.
0.375 = time to tie up one break.
1.60 = skeining factor.
X = maximum number of spindles to winding part.

In the above table it will be observed that the count is the only variable. Calling the count 1, we have the following formula, which gives a constant to calculate a table:

$$1 \times \frac{113{,}400 \times 0.375}{300{,}000} = 0.142$$

$$X = \frac{540}{0.142 \times C + 0.27 + 1.60} = \text{spindles.}$$

Count	Class	Theoretical spindles	Part	Basic spindles. Allowance, 5 per cent
16 to 18	Very well	126	120	114
18 to 20		118	120	114
20 to 22		111	115	110
22 to 24		105	110	105
24 to 26		100	110	100
26 to 28		94	100	94
28 to 30		90	100	90
30 to 32	Very well	86	90	86
32 to 34	Well	82	90	82
34 to 36		78	85	78
36 to 38		75	80	75
38 to 42		72	75	72
42 to 46	Well	66	70	66
46 to 50	Fair	62	70	62
50 to 54		58	60	58
54 to 58		54	60	54
58 to 62	Fair	52	60	52
62 to 66	Only fair	50	55	50
66 to 70	Only fair	47	50	47
70 to 74	Only fair	44	50	44
74 to 78	Poor	42	45	42
78 to 82		40	45	40
82 to 86		39	45	39
86 to 90		37	40	37
90 to 94	Poor	36	40	36
94 to 98	Very poor	35	40	35
98 to 102		33	35	33
102 to 106		32	35	32
106 to 110		31	35	31
110 to 114		30	35	30
114 to 118		29	30	29

Fourth, the winding rate is based on the maximum or basic number of spindles which shows an allowance of 5 per cent from

the theoretical number. The part, or number of swifts, given to a skilled winder is 10 per cent above the maximum number so she can average the basic number. Very speedy workers can exceed this table by 10 per cent and, when desired, they are given a part of 10 per cent above the average number of spindles run.

Pay According to Speed

Winders who are not skilled enough to keep the basic number running are given a part in accordance to their speed, and are

Date 1927	Lot	Part	No. Th'ds	Turn	No. Sp'dls	Count of Ends Idle										Aver.	Aver. Run	Sp'dle Run	Hours	Rate	Amount
1/15	56	110			115	10	5	0	0	5	8	5	0	2	5	4			9		
16	"	"			"	5	4	3	1	0	5	4	0	1	2	3			9		
17	"	"			"	3	2	0	0	1	3	0	1	2	0	2	3	115	9	31¢	
18	50	78			84	4	2	0	0	1	3	2	1	5	0	3			9		
19	"	"			"	1	5	6	2	0	0	4	3	2	0	3			9		
20	"	"			"	3	2	6	4	0						3	3	81	5	31¢	
																			50	31¢	$15.15
														GOOD SERVICE						2¢	1.00
																					$16.15

Earning Last Pay Rate Per Hour 32¢ Amount $16.00

Defects Found 10

Waste Made 180 Defects 5

Number 2500 Name MARY SMITH

Fig. 9.—Winders sheet on which record of ends idle is kept.

paid accordingly. The amount of work done by a winder on the counting-end rating system is determined by counting the number of ends down, at intervals of from $\frac{3}{4}$ to $1\frac{1}{4}$ hr. ten times daily. The number of spindles run is found by deducting the average number of swifts idle from the winding part given the winder.

When the silk is very bad and the part is under 45 swifts, then the ends idle may be counted fifteen to twenty times a day, if desired. The record is kept on an individual sheet for winder, as shown in the accompanying illustration (Fig. 9).

It is advisable to have the forelady count the idle swifts, as it keeps her informed as to the condition of her department.

When the ends are kept running, the idle swifts can be counted in 5 min. time, in a department of 30 machines.

The number of swifts to a part is changed as often as the count calls for it. Help do not object to an increase or decrease in the part when they once learn that they must work equally as hard on every lot. When there are many fine ends in the lot, the part should be reduced 5 or 10 per cent, as the case may indicate. On Cantons, old-style reel, an allowance of 20 per cent from the table must be made. On $^{16}\!/_{18}$ and $^{20}\!/_{22}$, the table must be corrected by changing the skeining factor.

The change in part may appear confusing, but, as one runs four or five different lots on a floor of from 35 to 40 machines, with a little planning one can get the maximum capacity of the winding machine with the minimum of trouble.

Production per Winder

The production of each winder can be closely determined as follows: The average efficiency of production per spindle will be 90 per cent. When soaked, $^{13}\!/_{15}$ denier silk averages in round numbers 300,000 yd. to the pound. On this basis, at an average of 204-thread speed, the production per winding spindle per hour is as follows:

$$\frac{\text{204-thread speed} \times 60 \text{ min.} \times 1 \text{ spindle}}{300{,}000} = 0.0408 \text{ lb. per spindle hour.}$$

At 90 per cent efficiency, we have $0.0408 \times 0.90 = 0.0367$ lb. per spindle.

On the American standard Japan $^{13}\!/_{15}$ raw silk skeins, the maximum average number of swifts run is 110, the minimum average 78, and the general average 94.

The production per hour at the maximum average and minimum parts is as follows:

		Pounds
Count $^{20}\!/_{21}$	110 spindles $\times$ 0.0367 =	4.037
Count $^{26}\!/_{27}$	94 spindles $\times$ 0.0367 =	3.45
Count $^{34}\!/_{35}$	78 spindles $\times$ 0.0367 =	2.864

Cost per Pound

The winding cost per pound is found by dividing the production per hour by the basic winding rate per hour, which we will fix, for example, at 30 cts. per hour. It varies in the trade from 10 cts. to 50 cts. per hour. The cost per pound at 30 cts. per hour is:

$$\text{Minimum } \frac{\$0.30}{4.037 \text{ lb.}} = \$0.0743 \text{ per pound.}$$

$$\text{Average } \frac{\$0.30}{3.45 \text{ lb.}} = \$0.0869 \text{ per pound.}$$

$$\text{Maximum } \frac{\$0.30}{2.864 \text{ lb.}} = \$0.1044 \text{ per pound.}$$

The weekly earnings of a winder working on a 110-, 94-, or 78-end part will be the same; on a 50-hr. week we have:

On a part of 110 spindles; minimum 4.037 lb. × 50 hr. × \$0.0743 = \$15.

On a part of 94 spindles; average 3.45 lb. × 50hr. × \$0.0869 = \$15.

On a part of 78 spindles; maximum 2.864 lb. × 50 hr. × \$0.1044 = \$15.10.

To determine the hourly rate for winders exceeding the part or running less than the basic number, the rate per spindle is first determined, using the basic number for each count and the basic hourly rate or set at 30 cts., thus:

Count $^{20}\!/_{21}$ on 110 spindles:

$$\frac{\$0.30}{110} = \$0.002727 \text{ per spindle.}$$

Count $^{26}\!/_{27}$ on 94 spindles:

$$\frac{\$0.30}{94} = \$0.00319 \text{ per spindle.}$$

Count $^{34}\!/_{35}$ on 78 spindles:

$$\frac{\$0.30}{78} = \$0.003846 \text{ per spindle.}$$

The hourly rate is found by multiplying the basic spindle rate by the number of spindles run, thus:

$$110 \text{ spindles} \times 0.002727 = \$0.30.$$

The following table gives hourly rate on parts of 110, 94, and 78 spindles:

TABLE A

Count 21. Part, 110 swifts		Count 29. Part, 94 swifts		Count 35. Part, 78 swifts	
Number of swifts	Rate per spindle \$0.002727. Rate per hour	Number of swifts	Rate per spindle \$0.003119. Rate per hour	Number of swifts	Rate per spindle \$0.003846. Rate per hour
130	35	112	36	93	36
126	34	109	35	90	35
122	33	106	34	87	34
118	32	103	33	84	32
114	31	100	32	81	31
110	30	95	31	78	30
106	29	94	30	75	29
102	28	91	29	72	28
98	27	88	28	69	27
94	26	85	27	66	26
90	25	82	26	63	25
86	23	79	25	60	24
82	22	76	24	57	22
78	21	73	23	54	21
74	20	70	22	51	20
70	19	67	21	48	18
66	18	64	20	45	17
62	17	61	19	42	16
58	16	58	18		
54	15	55	17		
		52	16		
		49	15		
		46	14		

A FAIR METHOD OF PAY FOR WINDING

A method of paying winders to be fair to both employer and employees must embody the following principles: First, it must reward the help for actual work performed regardless of production. Second, the employer must average the high cost of winding poor silk with a low cost of winding good silk and base his costs on these averages. It causes no labor troubles

to average costs, but lots of trouble when help earn low wages on poor silk and high wages on good silk. Third, help desire to earn a uniform wage and object to fluctuations, particularly so when they are under the average.

Unfair to Help

A fixed rate based on the average cost results in unfairness to the help and a higher cost to the employer, as shown by the following examples:

Winder A runs a part of 110 spindles on count 21; she produces 4.037 lb. × 50 hr. or 201.85 lb. per week, which, at an average rate of $0.0869 per pound, amounts to $17.54 per week.

Winder C runs a part of 78 spindles on count 35 and she produces 2.864 lb. × 50 hr. = 143.20 lb. per week, which at $0.0869 per pound equals $12.44 per week.

Both winders performed the same amount of labor, yet A earned $5.10 more than C. In actual mill practice C speeds up work, say 10 per cent faster than A, and earns $13.68, or still $3.86 per week less than A. When C discovers this, she generally asks for an allowance and only gets it, as a rule, if she puts up a good fight. If refused, she may quit or stir up trouble.

To avoid trouble, the rate is made high enough so that the help can make a fair wage on the poor winding silks, and, as they are generally limited on good silk by the capacity of the average winding part, the disparity in wages is not so great; but the help never become reconciled to the fact that on good silk they work less and earn more than on poor silk. Foreladies unfortunately sometimes find a way to give their favorites the good silk and the unfriendly ones the poor silk, which causes all kinds of trouble.

On the counting-end rating system if A and C run the basic part, both earn 50 hr. × $0.30, or $15, and the winding cost is the average of $\dfrac{0.073 + 0.1044}{2} = \$0.0894$ per pound. If winder A decides to work harder and keeps 118 swifts running

on count 21, she earns, according to Table A, \$0.32 per hour, on a 50-hr. week, 50 × \$0.32 or \$16 per week.

If winder C also decides to speed up and keeps 84 ends running on count 35, she also earns \$0.32 per hour or \$16 per week. The cost per pound is as follows:

Winder A, 118 spindles × 0.0367 lb. per spindle hour = 4.33 lb.
\$0.30 ÷ 4.33 = \$0.0692 per pound.
Winder C, 84 spindles × 0.0367 = 3.083 lb.
\$0.30 ÷ 3.083 = \$0.974 per pound.

The average winding cost equals $\frac{\$0.0692 + \$0.0974}{2} =$ \$0.0833 per pound, or \$0.0061 less per pound than when both run the basic part (when A earns \$5.10 more than C).

As soon as the winders discover the fairness of the method, they take to it readily. The skilled help work along at a steady gait, and do not vary much in their hourly rate from pay to pay. Beginners and partly skilled help vary in their hourly rate sometimes, but that is no fault of the system but is a case where the help want to be paid for being at work regardless of what they do.

This method soon eliminates the undesirable help; and it gives the employer the conscientious feeling that he is doing all he can to pay a fair wage for a fair day's work, and is in a position to demand a fair deal in return and build up an organization that responds to that kind of management.

Efficiency of Winders

To determine the efficiency of winders on the counting end rating system, proceed as follows:

First, determine the actual winding production by counting the number of skeins left over on each lot at the beginning of each week, and reduce to pounds by dividing the number of skeins left over by the number of skeins per pound. Add this weight to the weight of each lot soaked, and deduct the weight left over at the end of week. Take the count of each lot and multiply that by the number of pounds wound, average up, and determine the average count thus:

Lot A.	1,300 lb. wound	× count 25 =	32,500
Lot B.	1,500 lb. wound	× count 30 =	45,000
Lot C.	2,000 lb. wound	× count 28 =	56,000
Lot D.	2,500 lb. wound	× count 32 =	80,000
Total	7,300		213,500

$$213{,}500 \div 7{,}300 = 29.2$$

According to the table, 29.2 count calls for 90 ends at an average thread speed of 210 at 90 per cent efficiency, which produces 90 × 0.0367 lb. = 3.303 lb. per hour, which at 30 cts. per hour costs \$0.30 ÷ 3.303 lb. = \$0.0908 per pound to wind. Then determine the actual cost per pound according to payroll of operators. Let us say that this is \$0.093 per pound. The efficiency of the winding is

$$\frac{\$0.093 - \$0.0908}{\$0.0908} = \frac{\$0.0022}{\$0.0908} = 0.0242$$

$$0.0242 \times 100 = 2.42 \text{ per cent loss, or}$$
$$100 - 2.42 = 97.58 \text{ per cent efficiency.}$$

Waste in Winding

Studies on the amount of waste necessarily made in winding show that it is dependent on the number of breaks and the skein formation, and that it is lowest on the American standard skein and highest on the old-style Canton skein. The most skilled help can wind at 0.01 times count, expressed in per cent, or on count 30, 0.01 × 30 = 0.30 per cent. The average skilled help make about 0.015 times count. Under ordinary conditions where no effort is made to keep the waste down to the minimum, it is a common occurrence to find the average waste 0.025 times count, or equal to 3 cts. per pound. Cutting off a ring with from 20 to 25 threads is a common occurrence in some winding rooms, and it is only when expert teachers are employed and where constant vigilance is kept that the waste is held down to 0.015 times count. The common excuse that is made by the forelady when the subject of high waste is discussed is that, if one disciplines the help for making excessive waste,

then the winders put the waste in the toilet and it clogs up the drain or that they take the waste home and destroy it.

To combat these practices, which one meets everywhere, I used the following methods with good results:

1. In large winding rooms keep expert teachers who wind with waste of but 0.01 times count, and have them instruct all new help.
2. Permit no one to cut off rings and bad skeins, but set these out at the end of the machine and have them fixed by the teacher.
3. Gather all waste at noon and night and put it into an individual bag or box and weigh up in grams weekly. Skilled workers should not exceed 200 gm. a week on $^{13}/_{15}$ silk.
4. Pay a good service rate, about 10 per cent higher than the regular rate, to those who keep within the limit.
5. When the drain pipe becomes stopped up with silk waste, make surprise collections of waste at 10 a.m. and 3 p.m., besides the regular collections at noon and night, examine the amount and character of waste of each winder, and compare the amount with what she usually passes in. In this manner one can readily find the winder or winders responsible for the waste in drain pipes.
6. Do not discipline winders for making excessive waste until you have shown them a better way; then if they do not respond to reason and teaching, there is but one remedy; that is to dismiss them.
7. At times when we could not pay a good service rate, we appealed to their sense of honor, divided them into three classes, and attached a blue ribbon to the machine where the winders had the least waste, a red ribbon to the average class, and a yellow ribbon to those who made the highest amount of waste. We then put on several teachers and soon succeeded in getting all the yellow class into the red ribbon class, but never succeeded in getting all the winders into the blue ribbon class and holding them there until we paid a good service rate.

The efficiency of waste is determined by multiplying by 0.015 the average count of all silk wound, and dividing this result into the percentage of actual waste made. Cut

skein, ring, floor, winders', foreladies' and teachers' wastes are all included, thus:

$$\frac{\text{Actual waste made 0.40 per cent}}{30 \times 0.015 \text{ (average count) (factor)}} = 89 \text{ per cent waste efficiency.}$$

Kinks in Winding

Soft bobbins caused by slow spindles affect the first-time spinning and make loopy tram. Keep spindles up to speed by chalking the friction pulleys daily with mill crayons. I find the large size 1 × 3 in. the most economical and convenient. School crayons crumble under pressure and are wasteful.

Keep spindle heads smooth, as a bobbin driven by an uneven spindle head causes the threads to overlap and break down quite frequently on first-time spinning.

To prevent cotton cords from getting into the silk waste, have winders put them on their shoulders and collect them separately when gathering waste. It is a bad practice to throw them on the floor, for the winders also throw away a lot of silk waste with the cords; besides, it keeps the floor dirty, and frequently the cords when thrown on the floor fly into the running swift and go up on the thread, getting into the bobbin.

Gums rubbed out before putting skeins on swifts or before skeining give the best winding results. One cannot remove all the gums in soaking, because to open the skein sufficiently to do that would result in so many tangled spots (called knots) in the skeins that the winding cost and waste would be increased instead of decreased. The most efficient way I have found is to open up the skein full length and tie 10 skeins into a bundle with three strings. Use No. 48 braided banding, keeping the frayed ends clipped so they do not get tangled into the skeins. When they get hard and stiff, boil them in a strong soap-and-soda solution. The practice of opening up only the end of skeins and soaking in that condition does not give the most efficient winding results, as it leaves much of the gum unsoftened by the soaking solution.

Inspect and adjust thread guides daily to save labor cost and waste in fixing bad bobbins caused by imperfect guides.

To get the most perfect doubling, avoid hard bobbins; and to get the best spinning results, silk should be wound with 11 to 13 per cent of moisture.

Winding Silk Dry

On hosiery tram it is essential that the raw silk be wound dry if one wants an elastic stocking and desires to avoid a sleazy one. Winding raw silk wet permanently elongates the thread, which destroys part of its elasticity.

As the end on the skein is found easier and more quickly on dry silk than on wet, the winders' speed is greater and the waste is less, and this offsets the extra cost of hanging silk up to dry. If an efficient drying system is installed, the saving in winding will more than cover the labor cost of hanging up and drying. (See drying method given on pp. 132 to 134 of "Raw Silk Properties, Classification of Raw Silk, and Silk Throwing.")

Dry winding, however, is not a success unless the winding room is humidified and the humidity maintained during working hours at from 70 to 75 per cent at the same temperature. The humidifying system should be started two hours before working time so as to condition the skeins that have dried out during the night.

The winding breaks can be reduced from 10 to 25 per cent by maintaining proper air conditions. The gums in the skeins govern the breaks; for, when these gums are made plastic through a humid atmosphere, the thread pulls through without a break.

TESTS AND RESEARCHES ON FIRST TIME SPINNING

The first-time spinning process consists of spinning the single raw silk thread with from 12 to 18 turns per inch of left twist. The purpose of the twist is to unite the single filaments into a compact thread and add strength or resistance to wear. The higher turns are used when it is desired to twist in the small raw silk defects tighter and prevent their showing in the fabric or affecting working qualities.

Spindle Speed

The spindle speed varies from 10,000 to 14,000 r.p.m., depending upon the age of the machinery and management policies. On the higher speeds no tension or drag wires are used, and the thread passes through a centering eye, the function of this eye being to keep the thread over the center of the spinning bobbin and give good spinning results. At the higher speeds the cost of maintaining spindle belts, spindles, swing spindle holders, and idlers is excessive and out of proportion to the increased production obtained. The labor cost to assure a uniform twist is also much greater.

The twist, even with the best of attention, is irregular, as any slight obstruction in the spindle or belt causes the spindle to run proportionately slower so that a less uniform twist is obtained.

The power consumed is excessive, as it is not in proportion to the spindle speed, but is about in proportion to the square of the spindle speed. When no drag wires are used, or when the flat-coil type is used, many of the raw-silk defects such as waste, slugs, long knots, and bad casts, are twisted in on the thread, pass through all subsequent operations, and produce a lower grade of organzine.

Our studies showed that the highest efficiency of quality, or uniform twist and cleanness of the finished thread, was produced when using the 1 in. long Lovatt drag wires at a spindle speed of from 11,000 to 12,500 r.p.m. The cleaner thread also improved the doubling and second time spinning process. The extra labor required to tie up the increased breaks on first spinning was more than offset by the improved conditions in doubling and second spinning. Since the defects were fewer in doubling, the thread produced was more regular, and fewer corkscrews and loops were made.

At a spindle speed from 11,000 to 12,500 r.p.m., the efficiency of production was high, for there were few idle spindles waiting for repairs, few spindle belts to take up, few general breakdowns of machines, and there was no general overhauling required on a 124-hr. weekly run.

Efficiency of Production

The efficiency of production per operative and the labor costs per pound were found to be dependent on the following factors:

1. The quality of the raw silk.
2. The quality of the winder bobbins.
3. The atmospheric conditions (*i.e.*, temperature and humidity of the mill room).
4. The facilities provided for handling the winder bobbins, and the type of take-up shafts.
5. The width of spinner rolls, or rather the spacing of the spinning spindles.
6. The skill of operators on spinning.

The raw silk qualities required for the spinning of a good thread are: strength, pliability, cohesion, evenness, and cleanness. If a raw silk thread is inherently weak, such a thread should not be used for an organzine. Organzine is generally used as the warp in the loom where strength against breaking and resistance to friction are essential qualities. The torsion or spinning strain, together with an abrupt tension such as the thread gets when it catches on a knot or other defect, causes threads that are but 24 g. to break. Most of the spinning breaks are due to fine and very fine threads from 6 to 8 deniers in size.

If the thread is inherently weak, or shows an average strength of only 85 per cent, then there are threads that are only 70 per cent strong, and an 8-denier thread may then be only 22 g. strong and break down.

Strength is measured on the serigraph or serimeter, and is also called tenacity. It is expressed in grams per denier, or in per cent, 4 g. per denier representing 100 per cent when the test is made with a single thread on the serimeter, and 3.75 g. per denier when the test is made with 200, 300, or 400 threads on the serigraph.

The strength is sometimes indicated by breaking the thread by hand, and is judged by the condition of the ends of the broken thread. When the thread breaks off sharp, like a cut

thread, it is considered strong; when the thread breaks off with a number of irregular fibers, it is considered weak. This, however, is not always reliable, and only serves as an indication of weakness and suggests a strength test.

Pliability of Silk

The lack of pliability is called brittleness. A thread may be brittle against bending and also against pull. A dry atmosphere will cause brittleness. The sericin of silk, having a high cohesion and being a hard gum (as in Chinas and hard nature Japan) becomes, in a dry atmosphere, very brittle against bending. Under the spinning and bending strains, the hard gums often crack and present sharp edges to the fibroin, lessening its resistance to the bending strain and increasing the number of breaks. This brittleness can be remedied by a humid atmosphere, or partly remedied by a heavy oil soaking which makes the gum more plastic, overcoming the brittle condition and improving the running qualities.

Brittleness also appears in raw silk when one or more of the cocoons used in reeling the thread in the filatures are tender and brittle against pull. When these brittle fibers do not weaken the thread enough to cause it to break entirely in spinning, but only break themselves, a fuzzy organzine, which is noticeable only after dyeing, is produced. This condition occurs principally at the close of the silk season when the remnants of former years' crops are reeled up.

Brittleness also appears in raw silk when all of the cocoon fibers constituting the thread are brittle against pull and do not elongate more than 8 per cent. When these brittle threads catch on a knot, slug, or bit of waste on a bobbin, they may break down and cause excessive waste and labor cost. When they pass through spinning and doubling and are thrown into two thread, if a strain on the doubled thread stretches or elongates the thread 8 per cent, the brittle thread breaks and causes a split thread. This split thread often is pushed up into a ball and causes what is known as caterpillars. Threads that are brittle to pull and lack ductility or elongation also contract

differently from the threads having over 14 per cent elongation, and cause loopy corkscrews.

Brittleness may be measured on the serimeter, and is found by counting the threads that do not elongate more than 8 per cent. When 15 per cent of the threads elongate 8 per cent or less, the thread is very unsuitable for organzine or warp tram.

Cohesion a Factor

In spinning a thread that is open, or one with a low cohesion, one or more of the cocoon fibers frequently breaks when the thread runs against the head of the spinner bobbin, splitting away from the thread, running a band on the spinner bobbin, and breaking down the thread. When a cocoon fiber breaks, but does not break down the thread, a fuzzy organzine is made. A silk thread with a low cohesion also opens up when the take-up shaft runs idle on the spinner friction roll during the lunch periods or between shifts. This causes a flossy thread which must later be cut to waste before an end can be found to tie on to.

Soaking destroys from 10 to 50 per cent of cohesion, as is more fully explained in a former section on Cohesion. A silk thread suitable for a first-class organzine must have a good cohesion.

Cohesion is frequently tested by scratching the thread with the nail of the thumb; but one must be sure that the nail is not rough or sharp or it will cut the thread through before the thread opens up. While fairly consistent results for personal use may be obtained by one doing this kind of work continuously, the method does not permit of comparisons between different inspectors. Cohesion may be accurately measured on a cohesion machine, as was explained more fully in a former part of this treatise.

YARN DEFECTS

The evenness and cleanness defects that affect the spinning results are: very fine threads, waste, very long knots, very large loops, very large slugs, bad casts, split threads, and double

ends. The winder's defects are: cotton cords, winder's waste, and crossed ends.

The defects found in the raw stock may be counted in the spinning operations as the ends are tied up, counted by the Gage

BREAK TEST FIRST–TIME SPINNERS

Lot No. *SAMPLE* — Date *JAN. 1927*
Turns *16* — Stock *JAPAN*
No. of Spindles Run on Test *360* — Speed *12,500*

Raw Silk Defects		Total
Very fine ends	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	35
Waste	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸	40
Very long knots	𝍸 𝍸 𝍸 𝍸	20
Very large loops	𝍸 𝍸 𝍸	15
Very large slugs	𝍸 𝍸	10
Bad casts	𝍸 𝍸 𝍸	15
Split threads	𝍸	5
Double ends	𝍸	5
Unknown	𝍸 𝍸 𝍸	15
Total Silk Defects		160

Winder Defects		
Large winder knots	𝍸	5
Winder waste	𝍸 𝍸	10
Cotton cords	𝍸	5
Crossed ends	𝍸	5
Unknown		
Total Winder Defects		25

Raw silk defects	160	x Rule = 34	Breaks 300,000 yds.
Winder defects	25	x Rule = 5	Breaks 300,000 yds.

Note: Run test not less than 3 hrs. nor on less than 360 spindles.

Fig. 10.—Record of defects and breaks as kept by test spinners.

test, and also counted on block mirrors or the seriplane. To count them in the spinning operations, select conscientious spinners and teach them the various defects and how to classify and record them as they tie up the breaks, as shown by the form in the accompanying illustration. (See Fig. 10.)

Base the defects on 300,000 yd., determined as follows: At 12,500-spindle speed, 16 turns per inch, it takes 230 spindles 1 hr. to spin 300,000 yd.

$$\text{Yards per hour} = \frac{\text{(spindle speed) } 12{,}500 \times 60 \text{ (minutes per hour)}}{16 \text{ (turns per inch) } \times 36 \text{ (inches per yd.)}} = 1{,}302$$

To produce 300,000 yd.

$$\frac{300{,}000}{1{,}302} = 230 \text{ hr. on 1 spindle, or 230 spindles for 1 hr.}$$

Hence the breaks per spindle hour $\times$ 230 = the breaks per 300,000 yd. at 16 turns, which we will call x breaks.

Determining Spindle Speed

The spindle speed of a spinning machine may be determined by several methods:

It may be taken by a speed indicator or tachometer placed on the tip of the spindle; care must be taken that the speed is not retarded, and that a taper contact tip that fits tightly on top of the spindle is used. It is necessary on the swinging spindle to hold the spindle against the belt and avoid a wobbling spindle. The average should be taken from at least five spindles from different parts of the machine.

It may be obtained from the revolutions of the head-end shaft by multiplying the r.p.m. of the head-end shaft by the diameter of the spindle driving pulley and dividing this result by the diameter of the spindle whirl.

Example:

Speed of head-end shaft, 800 r.p.m.
Diameter of spindle driving pulley, 15 in.
Diameter of spindle whirl, 1 in.

$$\frac{800 \text{ r.p.m.} \times 15 \text{ in.}}{1 \text{ in.}} = 12{,}000 \text{ r.p.m.}$$

As a constant we have 12,000 ÷ 800, or 15; therefore, when the spindle driving pulley whirls are alike, fifteen times the speed of the head-end shaft equals the spindle speed.

It may be determined from the speed of the cork take-up rolls by multiplying the r.p.m. of the take-up rolls by the circumference of the roll in inches, and multiplying this result by the number of turns per inch for which the machine is geared.

Example:

Diameter of take-up roll, 3¾ in.
Circumference, 11.81 in.
Speed of roll, 70 r.p.m.
Turns per inch, 16.

70 r.p.m. × 11.81 in. × 16 turns = 13,227 r.p.m. When the circumference of roll and the twist are uniform, the constant is 189, or 189 times the speed of take-up roll equals the spindle speed.

It may be determined by finding the indicated feet per minute with a cut-meter, reducing the number of feet indicated by the cut-meter to inches by multiplying by 12, and multiplying this result by turns per inch.

Example:

Spindle speed 68 ft. per minute × 12 in. per foot × 16 turns = 13,056 r.p.m.

When the twist is the same, the constant is 192; and this, times feet per minute indicated, equals spindle speed.

Classifying Defects

A throwster should be able to give the manufacturer a correct report on the qualities of raw silk. This report cannot be based on the winding results, for poor winding is frequently due to hard gums, bad skein formation, and broken threads, none of which are the fault of the quality of the thread. Nor can it always be judged by the first-time spinning results, for poor winding silk may cause the winder to make poor work and have an excessive number of winder defects. A break test in spinning must therefore discriminate between the defects in the raw stock and those made by the winder. When these are separated as on the break form shown, and are classified accord-

ing to the following table, one gets a classification of the raw stock that has proved very useful.

First-time Spinning Breaks Due to Defects in Raw Silk

Based on 300,000 yd.	Classification
15 and under	Very good
16/20	Good
21/26	Fair
27/31	Only fair
32/39	Poor
Over 39	Very poor

The method of counting the defects by the Gage test (called the Defect Test in the 1926 *Report* of the Raw Silk Classification Committee), and the application to the working qualities in first-time spinning will be given at a later time.

Winder bobbins, to spin well, must be wound medium hard and level. The winder knots must be cut short, and waste and cotton cords must be kept out of the bobbins. A convex bobbin, or one where the silk piles up in the center when full, pays off in rings and breaks the thread. An irregular spindle head causes the bobbins to shift, and frequently crosses the threads, breaking the end. The heads must be kept smooth. Fiber heads should be buffed or polished about once a year.

I find the following the most efficient size of a first-time spinner bobbin:

Diameter of head, 2⅛ in.
Diameter of barrel, 1¾ in.
Length of bobbin inside of head, ¾ in.

Temperature and Humidity

The temperature in the spinning room quite frequently reaches 95° F. during the summer. My observation shows that spinners are inefficient when working under higher temperatures and relative humidities than those permitted by the English factory law, which are as follows:

Temperature, Fahrenheit	Relative humidity, per cent	Limit under English factory law, percentage
70	75	88
75	75	81½
80	70	77½
85	65	72
90	60	69
95	55	66

Experiments covering several years show that the breaks in spinning increase very rapidly when the relative humidity drops below 55 per cent, and slowly decreases as the humidity is raised to 65 or 75 per cent. At an air condition of 75° F. and 65 per cent relative humidity, silk regains from 11 to 11½ per cent moisture, or what is known as its normal condition.

According to a table compiled from Schloesing's experiments, a regain of about 11½ per cent on China raw would occur at the following temperatures:

Degrees Fahrenheit	Relative Humidity, Percentage
65	64
70	65
75	67
80	68
85	69
90	69
95	70

S. W. Cramer's table of regain on Japan silk shows 11½ per cent at 70° F. at 63 per cent relative humidity. Further studies on this subject are given on pages 215 to 235 of "Raw Silk Properties, Classification of Raw Silk, and Silk Throwing."

Handling Winder Bobbins

The most efficient method of handling bobbins, both empty and full, is to use bobbin boards and trays. Boards made to

hold 30 bobbins (three rows of 10 each) fit snugly on the winding and spinning frames, and are easily handled by the help. The routine of work in handling the bobbins is about as follows:

1. The boards containing the empty winder bobbins are carted up the aisle, and the winders place them on top of their machines.

2. The winder, when using an empty bobbin, replaces it with a full one just doffed off the winder spindle.

3. When the empty bobbins on the board are all replaced with full ones, the boards are set in front of the winding machine and tagged with lot and worker's numbers.

4. The boards with full bobbins are then gathered up by a truck boy, carted to the spinning floor, and stored on racks.

5. The spinner foreman gives out the silk to the spinners at stated intervals, and makes the spinner responsible for the silk. The spinners, in going after silk or winder bobbins, take back with them a board of empties.

Compare this method with the old-time one of handling the bobbins in baskets and trucks: There is a saving of about 60 per cent in labor in handling the bobbins and in the cost of truck or bobbins boys, with a material saving of waste and labor cost in spinning, for the bobbin heads are kept in much better condition. Since the silk can be easily marked, fewer mixtures occur, and the winder's work is much better, as bad work can be easily traced back to the person responsible for it.

Take-up Shaft or Bobbin

A take-up shaft that served as a take-up shaft on first-time spinning, as a frictionless doubler bobbin on 5B, and as a tram winder bobbin for crepe and tram, was designed and is pictured herewith. (See Fig. 11.) Note the following features of the shaft:

1. The hollow gudgeon on the head of the shaft serves as a tight pin when the shaft is used as a spinner take-up shaft. Since the gudgeon is only $^3/_8$ in. long, the shaft may be used as a frictionless doubler bobbin.

2. When used as a winder bobbin for crepe or tram, a winder spindle with an offset in the spindle head is required so that the head of the bobbin touches the spindle head.

3. As the threads on the first-time shafts on 5B's run off the side of shaft when doubling, they do not need to be steamed to set the twist, as no kinks are formed in doubling.

Other advantages of this bobbin are that it saves the labor of replacing loose gudgeons when doffing, and that there are no loose pins in it to shift out and cause the shaft to run at an angle on the take-up roll, causing the thread to pile up on one side of the shaft head.

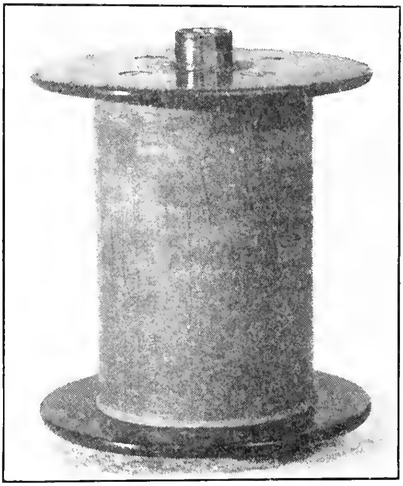


Fig. 11.—Used as take-up shaft on first-time spinning, as frictionless doubler bobbin on 5B, and as tram winder bobbin for crepe and tram.

The regular first-time spinner rolls are $2\frac{1}{4}$ in. wide; the second-time rolls are $3\frac{1}{16}$ in. wide. A number of advanced throwsters use the standard second-time friction rolls for both first- and second-time spinning, because of the greater efficiency and the convenience of making hard twists and other special threads. Owing to the closeness of the spindle on the narrow roll machines, the breaking end frequently swings over into the running thread, thereby causing 25 per cent of the breaks and unnecessary labor cost and waste. On the wide rolls this loss is reduced about 20 per cent. Because of the closeness of the spindles, flyers are difficult to use, and, when used, the small-sized bobbins make the cost of operation excessive. On the narrow rolls with loose-pin fiber shafts they have a tendency, when the rolls become worn on edges, to fill up unevenly and shift the top layers of thread over each other; this causes unnecessary breaks, excessive waste, and uneven doubling. The wide rolls overcome this defect to a large extent, and the losses are reduced to the minimum. They also permit the use of a larger shaft and spinner bobbin. The cost per pound, calculating 12 per cent as interest and depreciation on the cost of machinery and floor space, is about $\frac{1}{4}$ ct. per pound greater when wide rolls are used than when narrow rolls are used.

As a rule first-time spinning frames are operated 24 hr. per day without any stops between shifts or at lunch time. The hours of work on a 50-hr. week are, for the day shift, 7:30 a.m. to 12 noon, and 1 p.m. to 5:30 p.m.; and, for the night shift, 6:30 p.m. to 12 midnight, and 1 a.m. to 6:30 a.m.

The wages of the night shift are generally one and one-half times those of the day workers. Between the shifts and during the lunch hours a spinner or belt fixer remains on the floor and sets up the shafts on wire racks when the ends break down so as to prevent the thread from splitting or becoming flossy and causing bad doubling or tender places in organzine.

It has been found efficient to keep a helper or two, in a large spinning room, to assist in changing lots and getting parts filled up promptly and to help get ends running quickly after lunch periods and shifts. On very poor spinning lots, it is not efficient to run spinners between shifts and during lunch periods.

THROWING OF CRÊPE THREAD

As a large part of the silk looms today are operating on crêpe of one kind or another, we shall study the prominent characteristics of this thread as it occurs in throwing and manufacturing.

The principal products produced from crêpe silk thread are crêpe georgette, romaine, and Elizabeth, in which both warp and filling are of crêpe twist; and crêpe-de-chine, canton crêpe, crêpe meteore, crêpe charmeuse, and satin crêpe, in which the filling alone is a crêpe twist. The number of threads and twist generally used are as follows:

2 threads	75 to 90 turns
3 threads	60 to 65 turns
4 and 5 threads	55 to 60 turns
6 to 8 threads	45 to 50 turns

The Crêpe Effects

Crêpe effect in fabric may be produced in various ways, but the general practice is to produce it with hard-twisted yarn. Thread when twisted beyond its normal limit will develop a

tendency to kink, and the more it is twisted the more pronounced this kinking becomes.

The amount of pebble or granulation on the surface of the cloth regulates to a marked extent the twist in the thread. The customary method is to weave two picks of right-hand and two picks of left-hand twist alternately. If the goods are woven "pick and pick"—that is, one right and one left—the granulations will be less apparent. If woven four right and four left, the pebble will be much coarser. Therefore, two and two is the general practice.

Shrinkage of Fabric

The more the fabric shrinks, the greater will be the pebble effect. Other factors that must be considered are the relation of the amount of warp to the amount of filling, and the twist and size of the threads.

Boiled-off goods shrink more than goods in the gum; because, when the gum is boiled out, the contractive forces have full sway. Tin weighting increases the shrinkage about 5 per cent. The shrinkage is also influenced by the nature of the raw silk, as shown by the following test made on crêpe fabric constructed as follows: Thread, 4-thread twisted 40, 50, 60, and 70 turns: stock, XXA Canton $^{14}/_{16}$ denier, soft- and hard-nature Japans; fabric, all crêpe thread; shrinkage determined on fabric from measurements obtained before and after boiling off.

The results are as follows:

Stock XXA Canton $^{14}/_{16}$ Denier

Sample	Twist geared for	Range of twist obtained	Shrinkage of fabric, percentage
A	40	37 to 40	5
B	50	46 to 50	5.6
C	60	51 to 61	10.8
D	70	60 to 73	9

SOFT-NATURED JAPAN SHINSHU 13/15 DENIER

Sample	Twist geared for	Range of twist obtained	Shrinkage of fabric, percentage
E	40	35 to 41	4.96
F	50	45 to 50	5.95
G	60	56 to 61	9.2
H	70	68 to 73	7.88

HARD-NATURED KANSAI 13/15 DENIER

Sample	Twist geared for	Range of twist obtained	Shrinkage of fabric, percentage
I	40	30 to 40	4
J	50	43 to 48	6.2
L	70	63 to 70	6 5

These tests show that the canton thread shrinks the most, the soft-natured Japans come next, and the hard-natured Japans shrink the least. As these results were measured in the boiled-off fabric, it appears to indicate that the nature of gum or sericin also indicates the nature of the fibroin, and that measurements made on raw silk, for hardness and softness, will indicate its suitability for crêpes.

It has been found that the harder the sericin the more it resists elongation, and one might thus expect to find low elongation on hard-gummed silk and conversely a high elongation on soft-gummed silk, at the breaking point. This suggests the hypothesis that the measurement of nature might be determined from the elongation at the breaking point.

Extensive studies, however, do not prove the hypothesis, as 20 per cent of the threads are frequently found brittle against pull, or elongate only from 3 to 8 per cent, and affect the elongation values at the breaking point to such an extent as to prevent finding any constant relation between nature and elongation.

The buoyancy test, in which a sample of gum silk is placed on a hot liquor and the measurement of nature indicated by the time it floats on the liquor, is influenced by waxes, fats, dirt, and grease that collect in the reeling basins and run up on the thread. Degrees of softness between Japans and Cantons cannot be determined by this method. By confining the comparisons to each race of silk with itself, relative values in nature are found, but have only limited application.

The nature of raw silk can be correctly measured by stretching the thread wet at 1.4 grams per denier as given in section on Nature.

Soaking of Raw Silk for Crêpe

The object of soaking raw silk for crêpe throwing is scientifically to soften the reel marking or gums, prevent breaks in winding the raw silk from skeins, lubricate the thread to prevent the cutting of guides and flyers and reduce the breaks in twisting, and to make the thread more pliable so that the twist will set better and kinking in warping, quilling, drawing in, and weaving will be prevented.

Sellers of thrown silk sometimes soak it extra heavy so as to enhance its selling value, and unscrupulous commission throwsters sometimes do likewise to cover waste and theft of the raw or thrown silk.

The materials used for soaking are olive-oil soap; neatsfoot oil; olive oil; carbonated alkalies; proprietary oil, composed of neatsfoot and mineral; neatsfoot or olive treated with alkalies; neatsfoot, olive, and cocoanut oils treated with sulphuric acid; or sulphonated oils known by many trade names; and sulphonated oils compounded with minerals.

I will not attempt to treat the soaking of crêpe twist fully in this section as I do not desire to repeat what I have already written on the subject and which may be found in Part III of "Raw Silk Properties, Classification of Raw Silk, and Silk Throwing," but will confine this article principally to what has not already been said.

Neatsfoot, olive, and mineral oils of themselves do not affect the sericin, but they add weight and lubricate the thread.

Soap, alkalies, and sulphonated oils attack the sericin slightly, causing it to be become plastic, which makes the thread pliable.

An emulsion made of the proper proportions of either neatsfoot or olive oil, soap, and alkalies will make the gum plastic and the thread pliable, soften the gum, and lubricate the thread. Such emulsions absorb from 40 to 60 per cent of the anhydrous soap and oil used. In point of cost it is the cheapest soaking material giving satisfactory results.

A straight sulphonated oil, with an olive or neatsfoot oil base, is a poor lubricant and rarely absorbs over 15 per cent of the anhydrous material used. It, however, makes the thread pliable.

A compounded oil, consisting of mineral and sulphonated oils, is a good lubricant and makes the thread pliable. The thread absorbs from 40 to 80 per cent of the anhydrous material, depending on the proportion of mineral.

Many dyers, however, object to the mineral, because when used in excessive quantities they find it does not rinse out thoroughly and causes spotty goods. A combination of sulphonated oil and raw neatsfoot or olive lubricates the thread and makes it plastic. The thread absorbs from 40 to 60 per cent of the anhydrous material used. (By "anhydrous material" is meant the oil less the water required to process it.) Sulphonated products usually contain 25 to 30 per cent of water. Bar soap contains from 20 to 30 per cent of water. The sulphonated products are very penetrating and give uniform tinting and soaking return.

Boil-off Tests

The 1926 yearly Boil-off Report, published by the U. S. Testing Co. as per Table R, shows the minimum boil-off on Japan crêpe as 19 per cent and the maximum as 34 per cent. The minimum raw boil-off on Japan is given as 16 per cent and the maximum on Japan white as 24 per cent. The average is 18.49 per cent. The average boil-off on Japan white crêpe is given as 25.66 per cent, or showing an average absorption of 7.17 per cent of the soaking emulsion. A. Albertine in *Silk*,

August, 1927, gave the results of his investigations as in Tables S and T.

Mr. Albertine points out that 53 out of the 93 experiments show substances that are detrimental to the silk yarn in the dyeing process and should absolutely be avoided. He finds that large quantities of mineral oil, all kinds of greases derived from petrol, such as paraffin, vaseline, and all kinds of waxes, should be strictly excluded. He specifies that the loading of the thread should not surpass 5 per cent.

A recognized practice in the trade consists of trading in crêpe yarns on an 11 per cent regain and 25 per cent boil-off basis. We find that, of the 4,692 tests made at the U. S. Testing Co., 4,122 show between 18 and 19 per cent raw boil-off. This shows that the average 18.49 per cent represents a fair working basis for our study.

If we add to the average raw boil-off (18.49 per cent) a $6\frac{1}{2}$ per cent absorption of soap and oil, we get a crêpe thread with a boil-off of 25 per cent; but, as 7 cases in every 1,000 show 21 per cent raw boil-off and 58 cases in a thousand show 20 per cent raw boil-off, a silk soaked to absorb $6\frac{1}{2}$ per cent of emulsion might return with $21 + 6\frac{1}{2} = 27\frac{1}{2}$ per cent and $20 + 6\frac{1}{2} = 26\frac{1}{2}$ per cent boil-off.

Other conditions that affect the absorption are the acidity of the silk, the nature of raw, the porosity of the skeins in the soaking bath, the temperature of the bath, and the time soaked. This illustrates why the throwster cannot closely control the percentage of boil-off thrown, and any irregularity within 2 to 3 per cent cannot be considered as indicating excessive loading.

Observation covering a period of 15 years shows that crêpe thread having between 5 and 6 per cent of emulsion, when properly set by the throwster, gives good results in manufacturing except during the hot and humid summer days; then the excess humidity causes it to expand, makes it very plastic, and causes it to kink, which is very troublesome in warp twisting and drawing-in.

Trouble is also experienced in copping, quilling, and weaving. The remedy for this condition is to remove the excess humidity with a great change of air or, when possible, put the warps and

Table R
Loss in Boiling Off during the Year 1926

	16 %	17 %	18 %	19 %	20 %	21 %	22 %	23 %	24 %	25 %	26 %	27 %	28 %	29 %	30 %	31 %	32 %	33 %	34 %	Number of tests	Average loss 1926	Average loss 1925
Raw:																						
Japan, white	31	250	2,118	2,004	269	10	6	2	1											*4,692	18.49	18.77
Japan, yellow			3	31	126	249	301	80	9	1										800	21.37	21.74
Italian							2	14	30	11	3	1								61	24.03	23.40
China, white	31	77	108	28	8															252	17.65	17.78
China, yellow			2		1	3	10	3												19	21.47	19.22
Canton							9	89	37	2	1									138	23.25	23.30
Tussah											Variation 7 to 16 Per cent									378	10.70	9.84
Tsatlee				47	2															19	19.11	18.77
Organzine:																						
Japan, white			27	128	135	134	178	227	172	81	28	9	5							1,124	22.09	22.68
Japan, yellow							3	5	7	7	7	1								30	24.43	24.61
Italian									3	7	4	3	3	2	5	2		1	1	31	27.52	27.56
China														1						1	29.00	25.75
Canton													1							1	28.00	27.33
Tram:																						
Japan, white		5	15	42	44	71	75	121	209	164	88	43	17	6	5	3				908	23.59	23.95
Japan, yellow									1	1		1								3	25.33	32.00
Japan hosiery				5	41	127	568	1,635	1,429	783	309	139	58	23	10	6		2	1	5,136	23.80	23.43
Italian										4	4	9	8	7	10	4	2			48	28.37	30.09
China, white							1	1	4	8	8	7	3	11	9	4	2	1		59	27.66	24.70
Canton											1		4	2	2	14	11	5		39	30.95	28.77
Tussah						1	6	5	1		1		1							15	23.07	23.41
Tsatlee					1			1												2	21.50	24.67
Crêpe:																						
Japan				7	6	18	48	131	316	504	502	330	142	77	39	13	7	6	1	2,147	25.66	25.46
Canton										2	3	12	14	46	91	77	33	9	2	*290	30.22	30.09
Georgette				1		7	29	87	212	440	478	297	115	42	28	15	6	3		*1,762	25.79	26.07
China									3	5	6		4	2						20	26.15	25.66
Italian											1	4	5	9	9	2				30	29.90	29.86
Various tests																				1,946		
Total																				19,951		

* Includes one extreme.

TABLE S
PERCENTAGE OF WEIGHTING AND NUMBER OF TRIALS

Origin	Number of trials	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0
Crêpes:																					
Italian	36	...	...	1	1	...	...	5	4	1	2	8	2	7	1	3	....	1			
Canton	12	...	1	...	1	...	1	1	...	...	2	2	1	...	2	....	1				
Minchew	2	...	...	...	...	...	...	...	...	1	...	1									
Various	47	...	...	3	1	4	5	5	6	3	3	4	2	2	1	3	1	3			
	97	...	1	4	3	4	6	11	10	5	7	15	5	9	4	6	2	4			

Table T

Origin	Quality of the overweighting					
	Number of trials	Grease and soaps saponified with alkali	Grease, waxes, and soaps not saponified	Chlorides and sulphides	Magnesium and calcium	Iron
Crêpes	35	35	12	33	7	9
Italian	12	12	10	8	..	3
Canton	2	2	1	2	..	1
Minchew	44	44	30	10		
Various	—	—	—	—	—	—
	93	93	53	53	7	13

cops in a drying room which will contract the yarn, set the thread, and stop the kinking.

When the amount of loading is under 5 per cent, then the thread is subject to slight changes in the atmosphere and considerable trouble is experienced in weaving, particularly so in weave sheds where no humidifying systems are used or where they are installed but the relative humidity and temperature are not maintained.

The writer has never experienced any complaint with crepe thread having too much soap and oil that readily boiled out in the dyeing operations, but has heard of lots of trouble where parties loaded the silk with material that made the thread gummy and sticky and did not boil out readily.

METHOD OF THROWING CRÊPE

The most modern and efficient method of throwing crêpe consists of using a frictionless winder bobbin, doubling and twisting the thread three turns on the 5B type of machine, and then giving the full turn in one operation on the twisters on second-time spinners.

Winder Bobbins

The larger the winder bobbin the less the doffing in winding and the fewer bobbins to replace on the 5B's, consequently the greater the efficiency of labor.

It is found desirable to have the bobbin hold about one skein of raw silk, which weighs from $2\frac{1}{2}$ to 3 oz. on the standard American style. In designing the bobbin, the difference between the diameters of the barrel and head should not be so great as to make the tension on the thread between a spare and full bobbin enough to cause irregular doubling and a loopy thread.

Matching bobbins on the jack pins—that is, running a full bobbin with a full and a spare with a spare—is rarely done, as it delays the operator and increases waste and labor costs. As the thread unwinds off the side of the bobbin, the traverse may be $3\frac{7}{16}$ in. long, provided the jack pins on the 5B's, are long enough. It is advisable to use a frictionless bobbin, not only to reduce the tension and breaks on the thread but also to save power on the heavy threads.

The latest type of 5B's are equipped with swing spindles and are arranged for quick changes from right to left twist. The rings are about $\frac{3}{8}$ in. larger than the solid-spindle type, to allow for the swing of the spindle. This requires a bar traveler $\frac{1}{4}$ in. longer and somewhat heavier. A higher speed can be maintained on the solid spindle, but the swing-spindle type has many other advantages that are desirable.

Style and Care of Rings

On four-thread and under, the writer has had the most efficient results with a $2\frac{1}{4}$-in. cotton ring and traveler at a spindle speed of from 5,800 to 6,000 r.p.m., giving three and one-half turns per inch. To make a perfect bobbin for crêpe twisting, the bobbin must be wound hard and have a quick traverse. The hardness of the bobbin is regulated by the speed and the size of traveler. The life of travelers and rings are dependent upon the speed, care, and oiling. Travelers should give 1 week's service. The rings should be greased daily. The life of the rings on one side is from 1 to 2 years, depending on the care. The faster the traverse, the less waste is made in fixing a bad bobbin and the fewer breaks are had in spinning. The wind on the No. 78 5B bobbin should be about 18 to 20 warps once across the bobbin.

There are throwsters who use the cotton rings on all threads, and to prevent split ends change the traveler every 24 hr.

As the cotton travelers are light in weight, the writer has found that frequently the tension on heavy threads is not enough to feed the thread regularly, and more irregular twist is made on the cotton traveler on heavy threads than with the bar traveler. As the bar traveler also makes a harder bobbin, better twisting results are obtained when the 5B bobbins are made with a tram ring and bar traveler. The speed on tram rings and bar travelers on two and one-half to three turns is from 3,800 to 4,200 r.p.m. On the $2\frac{1}{4}$-in. cotton ring the No. 78 5B bobbin can be used, holding about 0.1385 lb. The $2\frac{11}{16}$-in. tram rings are generally used with the No. 78 5B bobbin.

Size of Part per Operator

The number of spindles an operator can tend are dependent on the following factors: (*a*) speed of spindles, (*b*) turns per inch, (*c*) kind of ring and size of traveler, (*d*) size of winder and 5B bobbins, (*e*) number of breaks, and (*f*) skill of operator.

The speed of spindles and turns per inch regulate the amount of thread twisted per hour or the production of the machine.

For our study we shall take as an example a two-thread, three and one-half turn, 5,800 r.p.m., using 300,000 yd. per pound single-thread (300,000 yd. per pound is about the average yardage per pound on a $\frac{13}{15}$ denier raw silk). The number of yards twisted up each hour is determined as follows:

$$\frac{5{,}800 \text{ r.p.m.} \times 60 \text{ min.}}{3\frac{1}{2} \text{ turns} \times 36 \text{ in. to yard}} = 2{,}761 \text{ yd. per hour.}$$

An average No. 78 5B bobbin holds 0.1385 lb., or $0.1385 \times 300{,}000 = 41{,}550$ yd. single-thread or 20,775 yd. of two-thread. The average winder bobbin holds 0.11 lb. or 33,000 yd. of single-thread.

Rate of working: Doffing the 5B bobbins, one bobbin takes 0.208 min.; filling up, one end, 0.50 min.; piecing up, one end, 0.50 min.; time unit, base on 1 hr. less 10 per cent or 54 min.

Doffing

If one 5B bobbin holds 20,775 yd. of two-thread and the spindle takes up 2,761 yd. per hour, one bobbin fills in 20,775 ÷ 2,761 = 7.52 hr. or 0.133 times per hour.

If one spindle requires 0.208 min. to doff, the 0.133 bobbins require 0.133 × 0.208 = 0.0276 min., which represents the doffing factor.

Filling Up

If one winder bobbin holds 33,000 yd. single thread and they empty at the rate of 2,761 yd. per hour, it will take 33,000 ÷ 2,761 or 11.9 hr. to empty or 1 ÷ 11.9 = 0.083 times per hour.

If it takes 0.50 minutes to replace an empty winder bobbin, the 0.083 bobbins will require 0.083 × 0.50 min. = 0.0415 min. As two bobbins are emptying at the same time, the filling-up factor is found by multiplying the number of threads, 2 × 0.0415 = 0.0830 min.

Piecing Up

The breaks on the 5B vary according to the number of cleanness defects, the number of very fine and weak threads, and the quality of the winder bobbins.

They range from 3 to 30 breaks on 300,000 yd. The average is about nine breaks on the single-thread winder bobbin. On the two-thread they are 2 × 9 = 18 breaks on 300,000 yd. As the machine is producing at the rate of 2,731 yd. an hour on each spindle, the breaks per hour will be (18 × 2,731) ÷ 300,000 or 0.1638 breaks. If one break takes 0.50 min. to tie up, the 0.1638 breaks will take 0.1638 × 0.50 or 0.0819 min., which represents the piecing-up factor.

If each spindle requires the following time in an hour for doffing, filling up, and piecing breaks, the total number of spindles that an operator can keep running is found by adding the three factors together and dividing the result into the time unit, thus:

	Minutes
Doffing factor	0.0276
Filling-up factor	0.0830
Piecing-up factor	0.0819
	0.1925

If one spindle in 1 hr. requires 0.1925 min. attention by the operator, the number of spindles an operator can keep running is found by dividing the 0.1925 into the time unit, or $54 \div 0.1925 = 280$ spindles.

Production per Spindle

Raw silk $^{13}/_{15}$ denier now averages near 14.30 deniers or nearly 300,000 yd. to 1 lb. On this basis one spindle running 1,000 r.p.m. and giving one turn per inch produces 0.0056 lb. in 1 hr., thus:

$$\frac{\text{Spindle speed (1,000)} \times \text{minutes per hour (60)}}{\text{Yards per pound (300,000)} \times \text{inches per yard (36)}} = 0.0056 \text{ lb.}$$

A two-thread, $3\frac{1}{2}$ turns, 5,800 r.p.m. will produce in one hour

$$\frac{2 \times 5{,}800 \times 0.0056}{3.5} = 0.01856 \text{ lb. per spindle hour.}$$

Then 280 spindles in 50 hr. will produce $280 \times 50 \times 0.01856 = 259.84$ lb. In actual practice about 90 per cent efficiency can be maintained, and the actual production that may be expected under very good conditions will be $259.84 \times 0.90 = 233.86$ lb.

Twisting Operations

The latest and most efficient method of twisting crêpe thread is to add all of the twist in one operation.

This can only be done when the doubled threads have a light twist, two turns or more, and by using the figure "4" flyers, as shown in Fig. 12, the figure "8" flyers as shown in Fig. 13, and the Universal four-arm flyer shown in Fig. 14. The figure "4" flyer is not balanced, and on high speeds causes the spindle to gyrate, increases the power consumption, causes

irregular and slack twist, and wears the spindle blades and spindle holders excessively. It also requires the use of a mill nut, which delays piecing-up. The space required on top of the spindle for the flyer and mill nut reduces the length of bobbin and its holding capacity. This decreases the part on 5B and

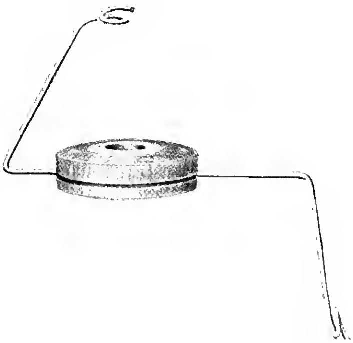


Fig. 12.—Figure four for crepe.

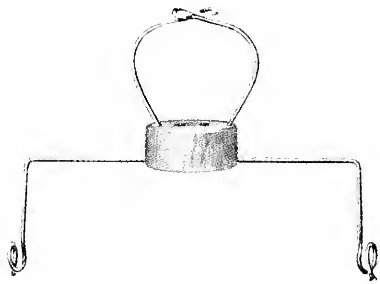


Fig. 13.—Figure eight for crepe.

twisting. The tension also is greater than necessary and on two-thread increases the breaks.

The figure "8" flyer has only one advantage over the figure "4," and that is that the flyer is balanced. Being heavier, however, it causes increased breaks on two-thread.

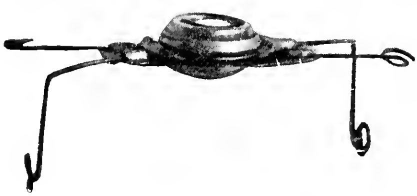


Fig. 14.—Four-arm flyer.

The Universal four-arm flyer is a combination of flyer and mill nut that can be set on top of a No. 78 5B bobbin, on the standard length second-time spindle blade. The thread passes through the two eyes in a way that puts very little tension on the thread, yet enough to keep it taut and prevent pin-head kinks and over swinging. It permits a uniform twist and can be handled quicker than any other type of flyer known to the author.

Advantages of One Operation

The advantages of giving all of the twist in one operation are as follows:

First, no knots are tied in the twisting operation. The ends are laid on instead. This prevents hard-twisted places at the knots and streaks in the fabric. Less time is required to replace an empty bobbin and start the thread after a break.

Second, there is economy in operation and less waste. An objection to giving the full turns in one operation that has been advanced is that if a spindle runs, say, 10 per cent slack, in putting in 70 turns there would be a loss of 7 turns, whereas if the twist is given in three operations, say 15 + 30 + 30, a 10 per cent slackness would affect the twist only from $1\frac{1}{2}$ to 3 per cent. It is further declared that, as the second and third twists are never added on the same spindle, the twist from three operations would be more uniform. Experience, however, shows that obtaining regular twist on crêpe threads is a matter principally of first-class equipment, speed, and care.

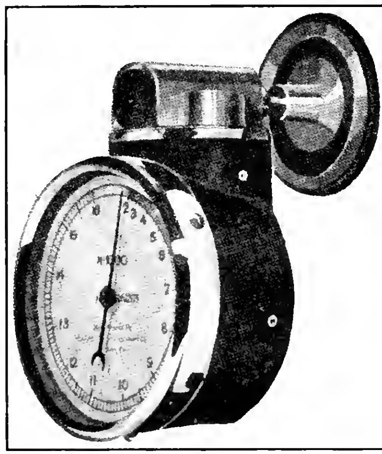


Fig. 15.—Direct-reading spindle-tachometer.

Tinkering with spindles is a very poor policy, and, when a spinning machine gets in such shape that it is constantly making slack twist, a general overhauling is necessary.

To get uniform twist the following attention is required:

1. Follow up daily every spindle. Feel the tension, and where slack repair the spindle. A more positive method is found by using a direct-reading spindle tachometer, such as is shown in Fig. 15.

2. Clean the spindle belts weekly. Hold a piece of soft chalk against the belt so as to absorb the oil, and then scrape the chalk off with a sharp knife, being careful not to injure the belt.

3. Test the tension on the spindle holders. Loosen up those that do not swing freely, and keep the spindle away from the spindle belt.

4. Keep the spindle belts tight and free from humps. Do not permit the belt to ride on the spindle-whorl flange, as that slows up the spindle.

5. Avoid speed much over 12,000 r.p.m., as above that the spindles require so much care that they cannot be followed up closely enough to produce uniform twist.

6. Make weekly twist tests on each spinner, starting with No. 1 spindle and following in consecutive order the other spindles on the machine. In this way in the course of time test every spindle on the machine.

7. When cleaning and oiling spindles, they should all be tried before the silk is put on the spindle.

Size of Part

Now let us calculate the size of part or the number of spindles that an operator can run on two-thread 70 turns per inch. We will base our estimate on the following equipment, speed and working rate:

5B bobbin No. 78 holding 0.13 lb. per bobbin of two-thread having three turns per inch and a spindle speed of 12,000 r.p.m.

Universal four-arm flyer.

A steaming take-up bobbin holding 0.08 lb. per bobbin.

Working Rates

Doffing one spindle, 0.10 min.

Filling up and laying on breaks, 0.50 min.

Time: As crêpe yarns are usually run 24 hr.—that is, without stops between shifts and at lunch time—the machines are, for about 16 per cent of the time, run without attention, except that of setting up the take-up bobbins off the friction rolls to prevent friction burns or chafing. As up to a certain limit it is less efficient to run spindles idle than to run a decreased part, the operators' time should be calculated on not less than 25 per cent of the full time operating and should be based on 25 per cent of 60 or 15 min. (60 − 15 = 45 min.).

A 2-thread 70-turn at 12,000 spindle speed produces in 1 hr. on one spindle

$$\frac{12{,}000 \times 60}{70 \times 36} = 282 \text{ yd.}$$

Doffing Factor

If one steaming bobbin holds 0.08 lb., it contains $(0.08 \times 300{,}000) \div 2 = 12{,}000$ yd. less 10 per cent shortening in twist, or 10,800 yd. If the threads twist up at the rate of 285 yd. an hour, the 10,800 yd. will take $10{,}800 \div 285 = 37$ hr. In 1 hr. the bobbin is empty $1 \div 37 = 0.027$ times. If one bobbin takes 0.10 min., the 0.027 bobbins that empty every hour will take $0.10 \times 0.027 = 0.0027$ min. as doffing factor.

If one No. 78 5B bobbin holds 0.13 lb., the number of yards are found thus: $(0.13 \times 300{,}000) \div 2 = 19{,}500$ yd. two-thread.

If the bobbins unwind at the rate of 285 yd. an hour, one bobbin empties in $19{,}500 \div 285 = 68.4$ hr. In 1 hr. the bobbin empties $1 \div 68.4 = 0.0147$ times. If one bobbin takes 0.50 min., the 0.0147 bobbins require $0.50 \times 0.0147 = 0.0074$ min. Add to this the time lost in covering large part or 50 per cent, and we have $0.0074 \times 1.5 = 0.0111$ filling-up factor.

Piecing Factor

A well-made 5B bobbin will average less than 10 breaks on 300,000 yd. On 1 yd. there will be $10 \div 300{,}000$ or 0.000033 breaks, and on 285 yd. twisted up each hour the breaks will be 285×0.000033 breaks or 0.0094 breaks. If one break takes 0.50 min., the 0.0094 breaks will take $0.0094 \times 0.50 = 0.0047$ min., plus 50 per cent time lost in covering a large part, or $1.5 \times 0.0047 = 0.0070$ piecing factor.

The total number of spindles are found by adding the following factors and dividing them into the time unit, thus:

	Minutes
Doffing factor	0.0027
Filling factor	0.0111
Piecing factor	0.0070
	0.0208

If one spindle in 1 hr. requires 0.0208 min. attention, the operator can run as many spindles as 0.0208 is contained in 45 min., or $45 \div 0.0208 = 2{,}160$ spindles.

In actual practice the maximum part is about 1,800 spindles, in order that a higher production per spindle may be attained. The production per spindle per hour $= 2 \times \dfrac{12 \times 0.0056}{70} =$ 0.00192 lbs. per spindle hour.

1,800 spindles $\times$ 0.00192 $\times$ 0.90 per cent efficiency 124 hr. per week = 385 lb.

Setting the Twist

Twisted yarns, taken directly from the twisting spindles, will kink up more or less, depending on the number of the threads and turns per inch. This is due to the tendency of the thread to untwist.

Processing to overcome the kinking is called "setting the twist." If one takes a thread of crêpe yarn and wets it, the thread will expand about one-half of 1 per cent and then slowly shrink to its contractile limit, if kept wet long enough.

If one stretches a dry thread of crêpe directly from the spindle about 15 per cent, the tendency to kink is reduced but the thread breaks before the kinking is overcome. A wet thread, however, given the same treatment, causes the kinking to be entirely overcome when the thread is stretched from 20 to 25 per cent. If one takes the same thread and repeats the trials it will again show a tendency to kink, but it grows less and less as the trials are repeated until the limit of contractile force is exhausted.

Obtaining Pliability

As the shrinking is greater in the boiled-off silk than in the gum, the nearer the gum silk approaches the pliability of the boiled-off thread, when the thread is steamed or soaked to set the thread, the more the contractile forces will be overcome, and therefore the better will the thread stay "put" or set.

Pliability of the gum thread is produced in soaking the raw silk, before winding, by making the gum or sericin plastic.

The amount of the soaking emulsion absorbed by the silk has an important relation to its plasticity. Mineral, raw neatsfoot, or olive oil has no effect on the sericin, except to add weight and lubricate the thread. An emulsion of soap, oil, and alkali does, however, make the thread plastic.

Observations covering many years show that from 5 to 6 per cent absorption is necessary to give the desired results. If a crêpe thread is worked in a damp room, it will kink again when the thread is slack. Sometimes this is active enough to cause manufacturing trouble. This is due to the moist air making the gum plastic and thus giving the fiber full sway in its tendency to untwist and kink.

The nature of the silk, method of setting the thread, pliability of the yarn, number of threads, and turns per inch, besides the humidity, govern the extent of the kinking.

Humid air, therefore, is not an ideal condition for twisting, drawing in warp threads, and warping crêpe yarns. Copping and quilling, however, are best performed in a relative humidity of from 70 to 75 per cent at about the same room temperature, as this causes the thread to become plastic enough to wind tight on the cops and quills and prevents undue slipping of the threads on the cops.

Soaking Method to Set Twist

The oldest method used to overcome the kinking, or to accomplish "setting the twist," consists of soaking the take-up shafts, bobbins or wooden rolls, upon which the crêpe has been wound in the twisting operations, in an emulsion of soap and oil or in clear water.

The time varies from several hours to over night. After removal from the bath, the silk is dried in the mill room or in a drying room. After the thread is dried, the twist is found set. The water or an emulsion of soap and oil in water softens and makes the sericin plastic, which permits the thread to shrink; the longer the time soaked, the more it shrinks.

The limit of contraction of the first wetting appears to be reached in an overnight soaking. When an emulsion is used

it adds weight to the outside of bobbins; but, as the emulsion is strained out by the outside layers of thread, very little emulsion enters the inside and the thread is irregular in the amount of boil-off thrown.

The objection to this method is the time and labor required to do the work, and when the emulsion is used several times the silk is unnecessarily stained with dirt that comes off the ends of shafts and crates. When clear water is used, it can be changed frequently and dirty crêpe thread avoided.

The objection to using a drying room is that it dries out the thread and the return weight is low in moisture content, causing a loss to the seller of that much weight. When iron heads are used, the heads rust in the bath, and where the rust gets on the thread it corrodes and tenders it.

Steaming Method

The method most generally used consists of steaming the bobbins or shafts from 15 min. to 1 hr. in a steaming room properly equipped to give a uniform distribution of steam and having an exhaust outlet and drain. When the thread has cooled off, after removal from the steaming room, the thread is found set. There are various modifications of this method, one of which consists of an iron pan about 8 in. deep, built into the bottom of the steaming room, which is filled with water and heated with a supply of steam. The vapor arising from it penetrates the thread, causing it to shrink; and on removal to the mill room and cooling off there, the thread is found set. The benefit of this method is that less steam is used.

Another steaming method consists of building a steaming room large enough to hold from 30 to 40 crates of shafts. The floor is built on a level with the mill room or provided with an easy run to and from the room.

A thermometer is placed on the outside of the door with the bulb extending inside. The room temperature is maintained at 190° F. The shafts are steamed 8 min., starting at the time when the room has reached the temperature designated. After 8 min. steaming, the steam is shut off and exhausted through a flue to outside air. The shafts are then moved to the mill

room for 5 min. cooling. This process is repeated three times on heavy threads, after which the thread is found to be set better than by any other method known by the writer. This method does not change the moisture content, and the thread regains closely the amount which it will absorb in the mill room. Iron heads must be avoided in this method also.

The latest method is called the vacuum system. This consists of an air-tight steaming chamber in which the silk is placed and the steam turned on about 1 min. more or less, as required. The steam is then turned off and cold water is sprayed on the jacket, causing the steam to condense and the air to contract, thus creating a vacuum, which sets the thread quite thoroughly and more quickly than by any other method.

Style of Bobbins Required

With the vacuum system, ordinary iron heads may be used without any trouble from rust corrosion. In steaming or soaking an ordinary iron-head bobbin, the steam condenses on the head and iron oxide or rust forms, permeating the water, which, by dripping on the silk, corrodes, tenders, or weakens the thread to such an extent that it breaks in warping and weaving.

Galvanized iron heads made with a gudgeon of steel with holes drilled into the heads and the heads turned down after galvanizing, expose a number of bare iron or steel spots to the action of the steam, causing rust. The rust-laden water occasionally drips on the thread. Weak spots are therefore not avoided by using such bobbins, unless the heads are drilled and turned down before galvanizing and the gudgeons are made of non-corrosive metal.

Copper- and brass-headed bobbins are too soft, bend, and become nicked very readily; besides, while no weak threads are made in using them, copper oxide or verdigris forms, attaches itself to the silk, and leaves spots on the thread that are not removed in boiling off. Spotted goods are thus produced.

Ordinary fiber-head bobbins warp in course of time, bind in twister take-up fingers, and must be occasionally replaced.

When brass screws and gudgeons are used, no weak spots are made.

Solid cast-aluminum bobbins with hollow barrels and heads well perforated are giving good results. The price and the fact that they become bent and nicked in handling are against their general use. When properly handled in crates and trays, satisfactory results are obtained. Rolled-aluminum heads with grooved wooden barrels are also made.

Bakelite heads fastened with brass screws with perforated heads and grooved barrels are giving good results. The prices are slightly less than for the aluminum heads.

Stainless-steel heads with gudgeons of the same material give excellent results. The prices so far are still rather high.

To get uniform setting of the thread, the depth of silk on bobbins should not be over ½ in. A bobbin with a head of 2½ in. and a barrel of 2 in. the writer finds satisfactory.

The traverse should give an open and slightly crossed wind so as to permit the steam to enter the thread properly. From 6 to 10 wraps across the standard second-time bobbin give good results.

Shortening in Twisting

The author has at various times investigated the shortening of crêpe thread in the twisting operations and has found that the pliability of the raw silk, weight and style of flyers, speed and tension on thread, temperature and humidity in the spinning room, and tension and moisture in the thread when redrawing on to the shipping bobbin have a decided influence on the shortening of the finished thread. He has not completed the researches, however, in a way that they might be used as a standard in cost calculations.

As the method of throwing crêpe varies greatly in different plants, it appeared that shortening values determined mathematically might be the most acceptable standard, provided they agreed closely with that found by practical test on crêpe thread properly thrown. With this object in view I submitted the problem to Prof. Thurman Andrews, a mathematician of recognized ability, together with a copy of "Serivalor," in which

Rosenweig treats the problem theoretically, and the article, in the Jan. 14, 1928, *Textile World,* on crêpe-thread yardage and take-up by Irving Lewin. In that article, Mr. Lewin gives a table of shortening values arrived at in mill practice, covering a period of 7 years. Prof. Thurman Andrews presents his treatise on the subject as follows:

Calculating Shortening

He bases the raw size on 14.17 denier, which was used by Mr. Lewin, and confines his calculations to the thread and twists given by Mr. Lewin. Professor Andrews says that it is a well-known principle of mechanics that if a symmetrical, isotropic, elastic rod is bent, the length of the axis through the center of the cross-section remains constant, and the part nearer the center of curvature (O in Fig. 17) is compressed while the part further away is elongated.

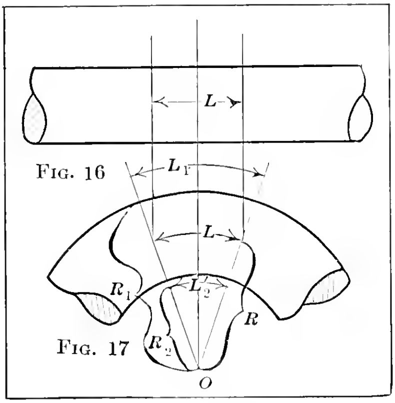
In Fig. 17, L remains constant. L_1 has stretched from the value of L to the value of $\frac{R_1}{R}L$. L_2 has been compressed from L to $\frac{R_2}{R}L$.

It may be shown that this is true for all possible ways of bending; and that, if the rod takes the form of a screw line (or corkscrew) O will be a point on the axis of the screw line. The important thing for our purpose is the fact that *half of the area of cross-section* lies on the side of compression and *half on the side of elongation.*

If two or more rods are twisted together, the common axis will be tangent to the rods, or will lie at the center of cross-section of the group of strands. Half of the cross-sectional area of the group will lie on the side of compression (the inner half) and the other half will lie on the side of elongation (the outer half). If the strands are not treated in a way to destroy the balance, by too much tension, and if the cross-sectional area of the group could be ascertained (including any open spaces such as would ordinarily be found when steel wires are twisted) the amount of shortening of the combined group could be ascertained with ease and with a fair degree of accuracy by

considering that the distance from the axis to the strand (L, in Fig. 17) that remains constant in length is the raidus of the circle of half the area of the combined group, open spaces and all.

If, in a material like silk, it so happens that the percentage of open spaces is no greater for a thread of several strands than for a single fiber, we may base our calculations on a circle having half the area of the several strands (we are assuming that the compression resulting from twisting would cause the strands to fit close enough together to compensate for any open spaces). The calculations are based on the assumption that the diameter of the thread is the same as the diameter of a circle made up by adding the areas of the cross-section of all the fibers or strands.



Figs. 16 and 17.

The diameter used in the calculations is the diameter of a circle having half the area of the combined areas of all the threads. The letter d represents the diameter of a single thread; N the number of threads; and D the diameter used.

The area of a single thread is $\pi d^2/4$.

The area of half the cross-section of the whole thread is $N\pi\frac{d^2}{8}$. Then $\pi\frac{D^2}{4} = N\pi\frac{d^2}{8}$ or $D^2 = N\frac{d^2}{2}$; therefore $D = d\sqrt{N/2}$.

It is thus observed that, when two threads are used, the diameter used is the same as that of one thread, or $D = d$. If four are used, we have $D = d\sqrt{4/2} = d\sqrt{2}$, etc. Since turns per inch are used, we will express the diameter D in terms of micro inches (1 micro inch = 1/10,000 in.).

The formula used to find the length of the strand that is neither stretched nor compressed is $L = \sqrt{P^2 + (\pi D)^2}$, where P is the length of one turn of twisted thread and D is the diameter of the cylindrical shell of threads that are neither stretched nor compressed. In "Serivalor" (p. 60), Rosenzweig gives 21.7 micro inches for size 14; for size 15, 22.5 inches; and for size

14.17 (the average used by Mr. Lewin), $21.7 + {}^{17}\!/_{100}(22.5 - 21.7) = 21.7 + {}^{17}\!/_{100}(0.8)$ 21.84 micro inches. 68 turns per inch gives 10,000/68 = 147.1 micro inches = P for one turn.

In two threads we get

$$L = \sqrt{147.1^2 + 68.51^2} = \sqrt{21{,}639 + 4{,}694} = \sqrt{26{,}333} = 162.2.$$

This is L by D; *i.e.*, length found by using diameter and length of twisted threads. L is the length of one turn of average yarn. P is the length of twisted thread. The shortening is $L - P = 162.2 - 147.1 = 15.1$, and the percentage of shortening $= (15.1 \times 100) \div 162.2 = 9.3$ per cent.

The theoretical shortening of the various threads in twisting according to the number of turns per inch given in Table U is determined by finding L by using P and D in the formula, D always being the diameter of a circle of half the combined areas of the cross-section of the threads, P the length of one turn of twisted thread, and L the length of the average strand, which is longer than P.

As these calculations show a close agreement with Mr. Lewin's results, on a number of items, I submitted the treatise to Mr. Lewin for review, and his reply to Professor Andrews for study. Both men carefully checked over their work and gave their kind permission to publish the results.

Mr. Lewin states that he is "entirely in accord with the statement made in the opening paragraph of this article as to the conditions that influence the take-up on crêpe thread." Professor Andrews says that "it is impossible to make a method of calculations that is 100 per cent correct, as the theory is based on too many assumptions"; but he finds that "the results are perfectly consistent for the conditions under which the method is supposed to work, and for the assumption taken."

It is very evident that, on account of the various conditions influencing the shortening of the crêpe thread in twisting, it is impossible to compile a set of tables that would be 100 per cent correct for all crêpe thrown in the states; while a table compiled of whole numbers from the results given by the two parties named would answer all practical purposes. Table U so compiled is submitted for further consideration and study.

TABLE U

Thread	Turns	Percentage shortening, Andrews	Percentage shortening, Lewin	Composite shortening table
2	65/70	9.3	8	9
2	70/75	10.5	8.65	10
3	60/65	11.6	11.08	11
3	65/70	13.1	11.56	12
3	70/75	14.7	12.05	13
4	60/65	14.6	13.18	14
4	65/70	16.5	13.83	15
4	70/75	18.3	14.48	16
5	55/60	15.3	13.35	15
5	60/65	17.3	14.15	16
5	65/70	19.4	14.96	17
6	50/55	15.38	16.42	16
6	55/60	17.67	17.40	17
6	60/65	20.14	18.36	18
6	65/70	22.19	19.34	19
8	50/55	19.1	17.07	18
8	55/60	21.7	18.34	20
10	45/50	19.4	19.01	19
10	55/60	22.4	20.63	21
12	40/45	19.2	20.31	20
12	45/50	22.1	22.25	22
12	50/55	25.3	24.20	24

The author was invited to present his studies on the shortening of crêpe thread to the Committees on Standardization of Cost Calculation, Division D, Broad Silk, and they have authorized through their field secretary, Edward Bersfield, the following statement:

It must be realized that Prof. Andrew's figures are based purely on theory and he assumes that all threads and twist will be run under exactly the same tension. Of course, from a practical standpoint this is impossible, as the higher twists and counts must under actual operation and practice be run by the throwster under a much heavier ten-

sion to avoid corkscrew and kinking, and this accounts to a great degree for the variation between the theoretical and practical results.

TABLE V

Thread	Turns	Average turns	D	C	P	L by D	Percentage shortening, Andrews	Percentage shortening, Lewin
2	65/70	68	21.84	68.51	147.1	162.2	9.3	8
2	70/75	73	21.84	68.51	137.0	153.1	10.5	8.65
3	60/65	63	26.75	84.04	158.7	179.5	11.6	11.58
3	65/70	68	26.75	84.04	147.1	169.4	13.1	11.56
3	70/75	73	26.75	84.04	137.0	160.7	14.7	12.05
4	60/65	63	30.87	96.98	158.7	185.9	14.6	13.18
4	65/70	68	30.87	96.98	147.1	176.2	16.5	13.83
4	70/75	73	30.87	96.98	137.0	167.8	18.3	14.48
5	55/60	58	34.48	108.30	172.4	203.6	15.3	13.35
5	60/65	63	34.48	108.30	158.7	192.1	17.3	14.15
5	65/70	68	34.48	108.30	147.1	182.6	19.4	14.96
6	50/55	53	37.80	118.76	188.6	222.8	15.38	16.42
6	55/60	58	37.80	118.76	172.4	209.3	17.67	17.40
6	60/65	63	37.80	118.76	158.7	198.4	20.14	18.36
6	65/70	68	37.80	118.76	147.1	189.0	22.19	19.34
8	50/55	53	43.63	137.0	188.6	233.1	19.1	17.07
8	55/60	58	43.63	137.0	172.4	220.2	21.7	18.34
10	45/50	48	48.83	153.4	208.3	258.5	19.4	19.01
10	50/55	53	48.83	153.4	188.6	243.1	22.4	20.63
12	40/45	43	53.48	168.0	232.6	288.0	19.2	20.31
12	45/50	48	53.48	168.0	208.3	267.6	22.1	22.25
12	50/55	53	53.48	168.0	188.6	252.6	25.3	24.20

D = diameter of circle of half area.
C = circumference of circle of half area = πD.
P = length of one turn of twisted thread (*i.e.*, the twisted thread as a whole).
L by D = length of average strand found by using D and P (*i.e.*, $L = \sqrt{P^2 + (\pi D)^2}$).
Percentage of shortening found by $[(L - P) \div L] \times 100$.

THROWSTERS CLEARANCES

Throwster clearances are affected by the following conditions:

First, the moisture contents in the raw. The invoice weight on Japan silk ranges from 0 to 2½ per cent over conditioning weight. The average invoice weight is about 1.70 per cent over conditioning weight.

Second, the amount of soaking emulsion absorbed by the raw, which varies from 3 to 7 per cent depending on the amount and kind of emulsion used and the nature of the silk.

Third, the moisture content in the thrown thread, which varies from 6½ to 11 per cent. (When loading is resorted to

for profit, the absorption is found at times to be as high as 12 per cent and the moisture content 15 per cent.)

Fourth, the amount of emulsion absorbed by the finished thread when the thread is set by the wet-bath method, and the extent of the drying after removal from bath.

Fifth, the amount of waste made, which varies from 2½ to 3 per cent, depending on the stock, method of throwing, and management. A fair average allowance on high-grade stock is 2½ per cent. On heavy thread the waste may reach 4 per cent when low-grade and poor-winding raw silk is used.

Sixth, mixtures, through accident or carelessness. As long as employes will be careless and make mistakes, so long will the throwster be troubled with mixtures. Various means are used to avoid them, such as tinting the silk in soaking, colored tags, different colors on the heads of bobbins, striping heads of bobbins, and methods of checking up—all of which are more or less helpful in reducing them to rare cases in a well-managed plant.

Range of Clearances

The first five variables show that actual mill clearances will at times range from ½ to 3 per cent. Yet many manufacturers have been led to believe that their clearances should not vary more than one-half of 1 per cent, that such returns indicate good management, and that when they vary greatly the proper amount of silk has not been returned to them. I know of instances where conscientious throwsters would not "fix" the returns and the business was given to others who were proficient at "fixing," keeping the owner happy and contented but blissfully ignorant of how it was done.

There are, however, practices that a throwster must follow during certain periods of the year that may appear to those having only a limited knowledge of the subject to be "fixing," but which are done to improve the quality of the delivered thread. I refer to the method of soaking heavier in winter to overcome the very dry mill conditions and improve the working qualities of the thread, and that of dampening the finished thread to wind a better cop and prevent slipping.

Many spinning rooms show a temperature of from 80 to 85° F. at a relative humidity of from 40 to 45 per cent during the winter months. This air condition causes the thread to become very dry and contain only from $6\frac{1}{2}$ to 7 per cent moisture, causing increased breaks and waste.

Silk wound on cops under such air conditions winds loosely and the thread frequently slips off the end. This is prevented by spraying the silk with water or conditioning the thread in a humid room before copping.

Effect of Conditions

I do not want to infer that all clearances ranging less than one-half of 1 per cent are "fixed," as that would be just as false as to say that returns varying under one-half of 1 per cent always represented actual mill returns. Throwing plants operated 24 hr. a day, with the air conditions properly regulated, using only Grand XX raw, and having a good organization and a steady run on the same thread and twist, do not show any radical changes in their clearances for months; but, when changing from winter to spring and from fall to winter conditions or getting a lot that runs poorly, it may cause unusual clearances. This, unless the conditions are understood, will reflect on the throwster and appear to indicate, in the case of low returns, that something has happened and that the return shows a loss of silk, while the changes in the season may be entirely responsible and the clearances show the actual return from mill.

To meet these conditions many of the modern throwing plants have installed testing laboratories to permit the throwster and his customer to determine without guess work the condition of the silk both coming in and going out of the mill, thus establishing the question of actual waste made.

Are 100 per cent clearances absolutely correct when all of the loading boils out? No, because only 10 per cent of the raw and thrown silk are tested, and double and triple the number of tests made on the same silk often show considerable variation in the average results. As the shipping bobbins give and take moisture, the exact return weight cannot be determined until

all of the bobbins are emptied. It is, however, good business practice to deal on a 100 per cent basis, provided the amount of waste allowed for the grade of silk used is reasonable.

Does It Pay?

Does it pay the owner to spend about 2½ to 3 cts. per pound to have 100 per cent clearances made on all crêpe thrown on commission? That depends entirely upon what service the throwster is giving, and that can only be determined from a trial on the 100 per cent basis, and a careful analysis of all conditions involved. Where any doubt exists it is wise to exercise the following precautions:

1. Inquire carefully into the character of your throwster, and, if he stands the test, give him a fair deal; don't expect the impossible. Make 100 per cent clearances occasionally for your information, his knowledge, and to avoid temptation.
2. Buy thrown crêpe thread on a definite boil-off and condition-weight basis. Send all silk to the testing house for net weighting.
3. Occasionally when the thrown thread appears unduly heavy in size, after allowing for take-up in twisting, as given in Table U, have a chemical analysis made on the thread to learn whether material has been used that does not boil out, particularly so when low boil off and heavy thrown size indicate that this might have been done.

The practice of trading on a specific amount of waste, charging the throwster for any excess waste above that amount, and not allowing any credit on lots where the waste is lower, or on a reciprocal basis, is very bad business, because it tempts the throwster to hold back silk to make good his losses or treat the silk so the returns will be in his favor.

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